The Welding Engineer

Reg. U. S. Pat. Office

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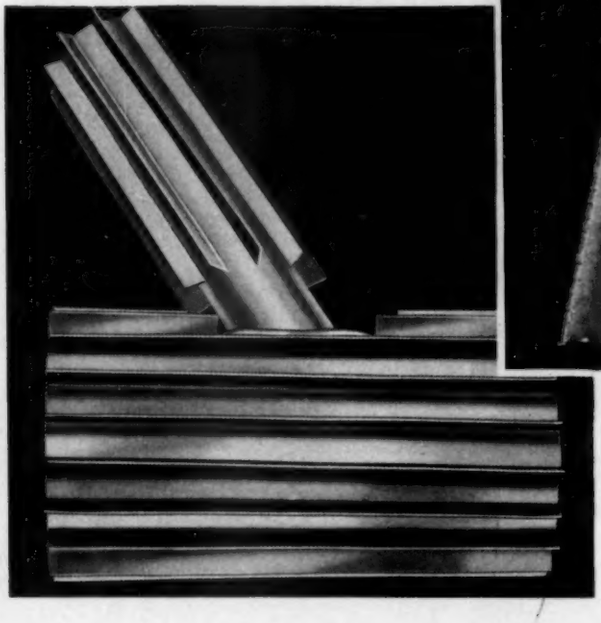
Tips on the gas welding of ENDURO



Gas or acetylene welding is used quite extensively and successfully in the welding of Republic ENDURO Stainless Steels, especially in the lighter gauges—18 gauge and thinner.

The flame should be as small as possible, yet produce good fusion. The ideal flame would be neutral, but since this condition is difficult to maintain, a slight excess of acetylene is advisable to prevent a burnt porous weld. A flux should be applied on the bottom side next to the edges, and in some cases also on the top side. It is advisable, wherever possible, to clamp the sections in a jig to hold the edges in line. If the edges are held apart half the thickness of the sheet, good fusion can be obtained by merely holding the flame against the work, allowing the edges to melt and fuse with the filler rod. The rod should be held in the flame at all times.

You will find these tips and many others in Republic's Booklet No. 116—"The Welding of ENDURO Stainless Alloys." Send for a copy today.

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THE WELDING ENGINEER

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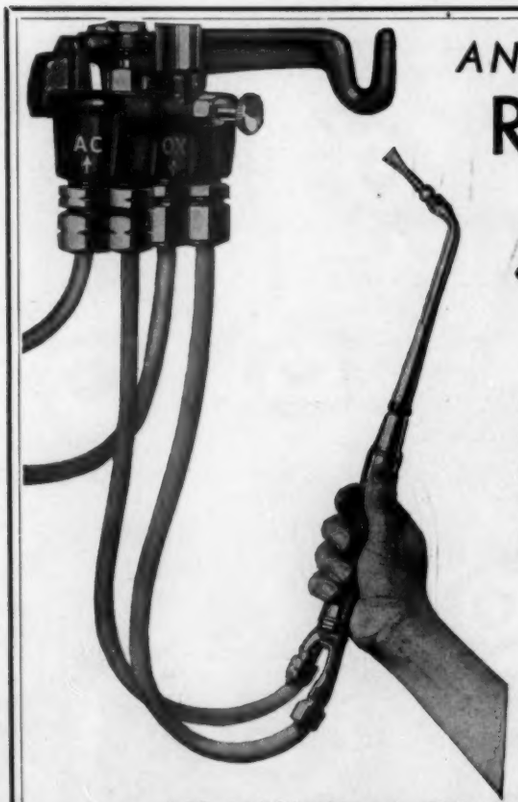

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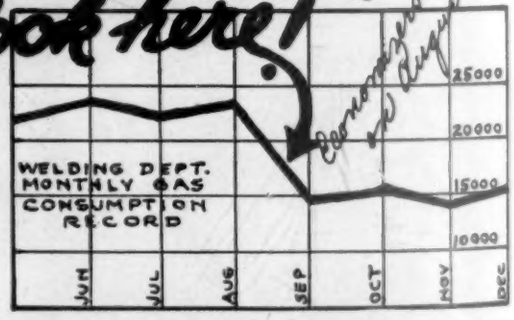

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The Welding Engineer

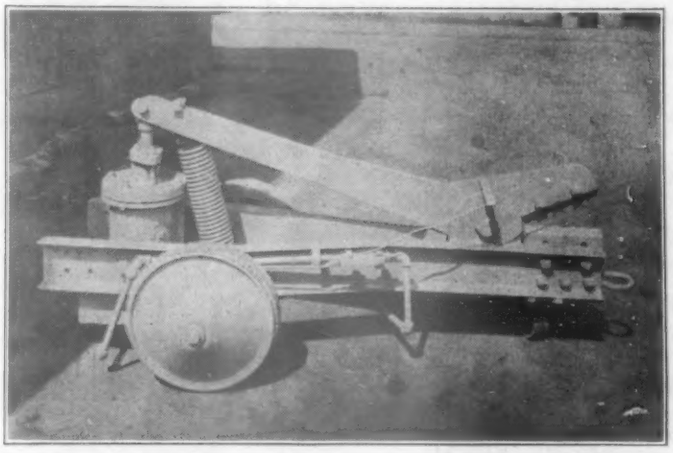
VOLUME 20 AUGUST, 1935 NUMBER 8

A Simple Design for a Pair of

Welded Portable Pneumatic Shears . . .

■ By W. S. WHITING, JR.
The Champion Fibre Company

HERE is a set of sturdy shears, proven by two years of service, that overcomes one of the worst features of steel work—namely, the handling. Instead of carrying long rods into a crowded shop from a remote pile to have them sheared to certain lengths, this machine can be wheeled to the location, hooked to an air line, and operated with a high degree of speed and safety. The design, based on low cost to build, includes only standard structural shapes and parts to be found around the least pretentious of shops.

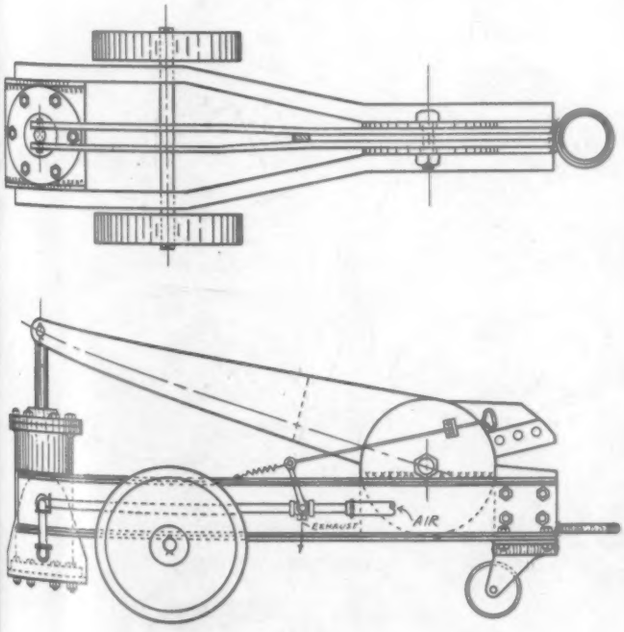


View of Welded Shears

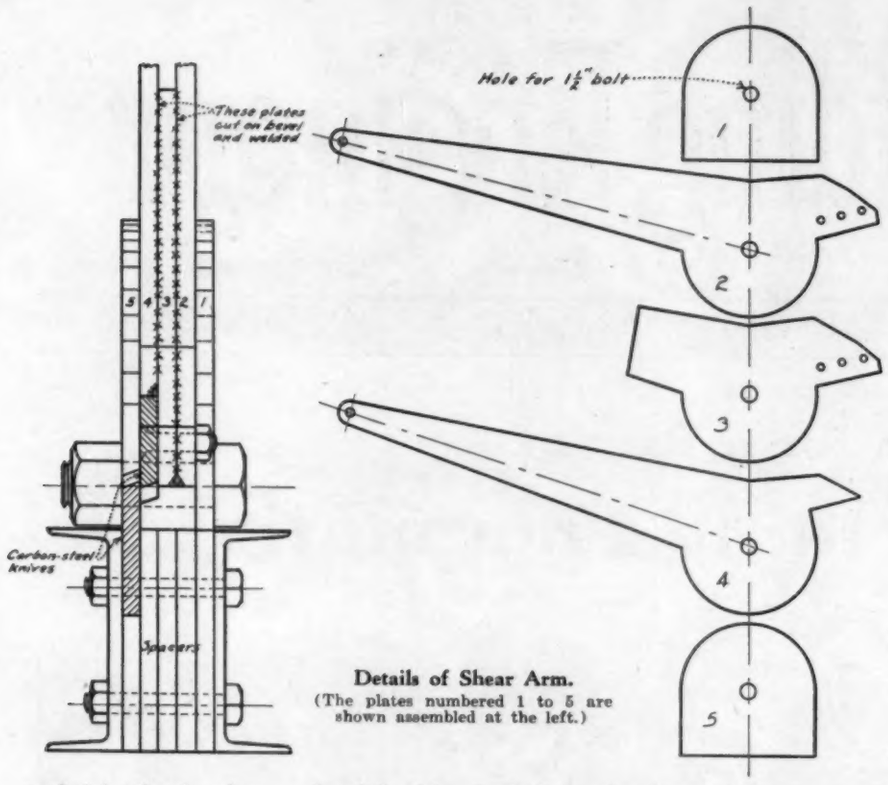
The machine in the picture was built by the writer when he was with the salvage department of the Champion Fibre Co., Canton, N. C., to cut up scrap tubing and reinforcing, and has been used to advantage for that and other jobs since. The source of cutting power was a discarded 8-in. air-brake cylinder, which with an air pressure of 100 lb. per sq. in. gives about 4,800 lb. on the end of the arm. A 4-to-1 leverage raises the power to about 20,000 lb. at the shear, which is sufficient to cut 1-in. round iron.

The air cylinder sits in a cradle made of ½-in. plate which is pivoted on each side to the 6-in. channel-iron frame members. This feature takes care of the eccentricity of the end of the arm, as it rises. The arm from the wrist pin to the center of the fulcrum is 48 in., and from the fulcrum to the tip of the knife is 15 in. A set of 18-in. discarded jitney rubber-tired wheels are so placed as to carry most of the load. A swivel caster is bolted to the legs of the channel, making for ease in moving the machine. In the elevation drawing is shown the 3-way valve and means for operating the shear. This feature is particularly desirable in that the operator has to take one hand to pull the lever while he steadies the piece with the other hand, making for greater safety.

The shear arm is built of ½-in. boiler plate, and those pieces numbered 2, 3,



Plan and Elevation Drawings.



Details of Shear Arm.
(The plates numbered 1 to 5 are shown assembled at the left.)

and 4 in the drawing are beveled with the cutting torch and emery so that a complete edge weld may be obtained. Pieces 1 and 5 are welded to the channel irons.

The knives used were pieces of old wood chipper knives, cut and ground to size, which proved very satisfactory. The bottom knife is held in place by spacers and four ⅝-in. bolts. Clearances were made wherever needed by adding shins to the spacers.

To increase the speed of recovery after cutting, weights or springs may be put on the arm. A coil spring placed inside the cylinder around the piston rod is the best way to achieve that end.

If one is considering a more powerful machine, the parts should be made proportionately stronger.

International Congress of Oxyacetylene Welding

The Twelfth International Congress of Acetylene, Oxyacetylene Welding, and Allied Industries will be held in London, England, June 8 to 13, 1936, under the direction of The British Acetylene Association. This Congress will mark the 50th anniversary of the industrial production of oxygen in Great Britain and the centenary of the discovery of acetylene.

The purpose of the Congress, as announced, is the scientific, technical and economic study of questions relating to calcium carbide, acetylene, oxygen, oxyacetylene welding, and to their various applications.

Communications to the Congress are invited, in the form of papers or of films. Papers must reach the General Secretariat, at 1 Albemarle St., London, not later than May 31, 1936.

Program for American Welding Society Fall Meeting

The program for the Fall Meeting of the American Welding Society, to be held in the Palmer House, Chicago, the week of Sept. 30th, in addition to general papers and reports on fundamental research, includes two symposiums—one on minimizing distortion, and the other on the application and welding of low-alloy steels.

The technical sessions will be on Monday afternoon and both morning and afternoon of Tuesday, Wednesday and Thursday. Friday will be given over to inspection trips. The annual banquet will be held Thursday evening, and the Fundamental Research Committee meets Tuesday evening.

The following papers are on the tentative schedule:

"Welding of Steam Piping," by Gilbert D. Fish, consulting engineer.

"Bridge Welding," by F. H. Frankland, Vice-Chairman, Committee to Study Welding of Highway and Railroad Bridges.

"Spot-Welding Problems," by J. H. Zimmerman, Massachusetts Institute of Technology.

"Bend Testing of Welds," by M. F. Sayre, Union College.

"Advantages of Welding in Continuous Structures," by Inge Lyse, Lehigh University.

"Properties of Pure-Iron Welds as Compared With Commercial Steel," by Gilbert E. Doan, Lehigh University.

"Investigations of Residual Streases," by R. E. Jamieson, McGill University.

"Nitrogen in Metallic-Arc Weld Metal," by J. W. Miller, Reid-Avery Co.

"Low-Temperature Tests of Welds," by Otto Henry, Brooklyn Polytechnic Institute.

"Creep Tests of Welds," by N. F. Ward, University of California.

"Tests to Determine the Feasibility of Welding the Steel Frames of Buildings for Complete Continuity," by W. M. Wilson, University of Illinois.

"Welding All-Metal Radio Tubes," by W. H. Gibb, Thomson-Gibb Electric Welding Co.

"A New General-Purpose Meter for Resistance Welding," by C. Stansbury, Cutler-Hammer, Inc.

"Machine Torch Cutting in Fabrication of Tool Equipment," by Mr. Shake, Delco Products; K. Jamerschefski, superintendent steel production, and G. Danly, Danly Machine Specialties Co.

"Effect of Generator Characteristics on the Weld," by J. H. Blankenbuehler, Westinghouse Electric & Mfg. Co.

"Welding of Alloy Steels," by J. C. Hodge, The Babcock & Wilcox Co.

"Fundamental Electric Characteristics of the Welding Arc," by S. C. Osborne, Wilson Welder & Metals Co., Inc.

Symposium on Methods of Minimizing Distortion: Pressure Vessels, by J. T. Phillips, Foster Wheeler Co.; Structural Welding, by John B. Hendrickson, of John B. Hendrickson, Inc.; Machinery, by R. E. Kinkead, consulting engineer; Repair Welding, by Geo. Hettrick, Anchor Welding Service, Inc.; Light-Gauge Steel, by J. H. Blaha, General Household Utilities Co.

Symposium on Low-Alloy Steels for Welding Purposes: "The Development and Use of Low-Alloy High-Tensile Steels in Welded Construction," by A. E. Gibson, The Wellman Engineering Co. "Welding of Alloy Steels," by J. H. Critchett, Union Carbide & Carbon Research Laboratories; H. M. Priest, U. S. Steel Corp.; Mr. Dillon, Struthers-Wells-Titusville Corp.; A. J. Moses, Hedges-Walsh-Weidner Co.; T. McLean Jasper, A. O. Smith Corp.

The full program will be printed in the September issue of *The Welding Engineer*.

Concurrent with the meeting of the American Welding Society, the National Metal Congress will hold forth in the International Amphitheatre, at the stockyards. This will be the largest metal show held in five years, according to W. H. Eisenman, managing director.

Rebuilt Oil Plant Employs Welded Steel Construction

Restoration of the Canfield Oil plant at Coraopolis, Pa., which was destroyed by fire on June 9th, has been completed by The Austin Co., Cleveland, Ohio.

The project required erection of ten filter tanks, and one earth bin in a 3-story, 41x63-ft. filter house of welded steel construction and brick exterior. The structural work began on June 26th, on which date the site was finally clear of all wreckage. On July 20th the filter tanks were prepared for operation with a fill of fuller's earth. Actual filtering began July 22nd, and the first motor oil was ready for the market on July 25th. Restoration of the filter house was completed on Aug. 12th.

In order to eliminate all possibilities of leakage in the future all pipe connections throughout the filter house were welded, Austin engineers explained. This eliminates the chance that leaks will be caused by vibrations resulting from train movements on the Wheeling & Lake Erie railroad tracks alongside the Canfield plant.

Coca Cola Equipment Welded From Stainless Steel by the Radford Sheet Metal Works of Los Angeles, Calif.

Welding the Stainless Steels

(Copyright 1935 by A. P. Johnston)

■ By A. P. JOHNSTON

THE terms KA2 and 18-8 refer to the same alloy steel, containing about 18% chromium and 8% nickel. To make it suitable for welding, the steel may be low in carbon to resist corrosion after welding. This low-carbon grade has less than 1/10th of 1% carbon and is sometimes designated by the letter S, thus: KA2-S and 18-8-S. The maximum carbon content should be specified when purchasing.

The 18-8-S, referred to as "stainless" in this article, is ductile before and after welding. It is welded with a coated rod of 18-8-S, likewise referred to as "stainless" herein. This weld is also ductile.

Illustrating Dilution of Weld Metal by Parent Metal.

(Since the whole weld area is of uniform alloy composition, the percentage composition is in proportion to the two areas.)

If, however, the sheet is welded to ordinary steel with this rod, the weld may not be ductile. The trouble is due to mixture of the 18-8 weld metal with ordinary steel, which produces an alloy of a new kind, having new and different properties. This weld should be made with 25-12 rod, which after dilution is about 18-8.

Bead Comprises Rod Metal Diluted by Parent Metal

Dilution of the rod metal by the parent metal must take place. The resulting weld metal may be safely figured as being 2/3 rod metal and 1/3 parent metal. For this reason, stainless-steel-clad metals, junctions of stainless and ordinary steel, and beads of stainless on ordinary steel must be made with a higher-alloy rod if the weld metal is to have the 18-8 stainless characteristics.

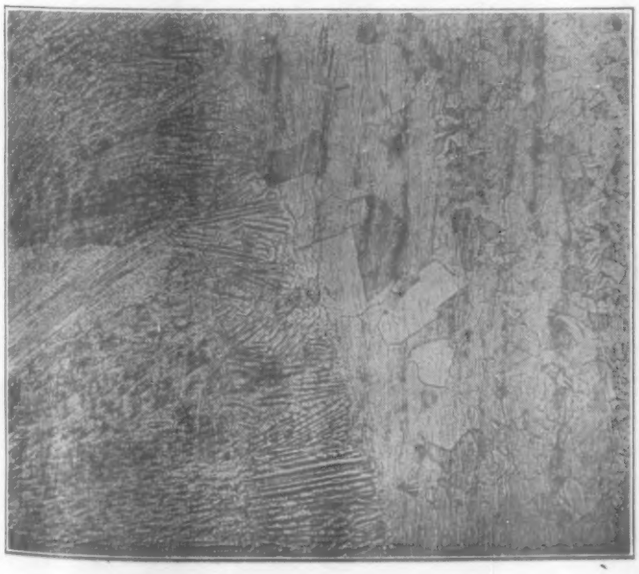
Welding of the stainless-clad metals with a rod of, say, 25-12 requires the use of larger-diameter rod than for a like gauge of straight stainless, because of the higher heat conductivity of the base metal. This factor is important, since overlooking it will result in attempts by the welder to secure penetration and shape of weld by overheating the rod or puddling.

Straight Chrome Steels Can Be Welded With 18-8 Rod

Welds on 4 to 6 chrome, 11 to 13 chrome and 16 to 18 chrome steel may or may not be satisfactory if made with 18-8 rod. Ductility in the weld can be secured by the use of welding rod of higher nickel content than the 18-8. The parent metal, however, will be hardened by the heat of welding and is not ductile, after welding, in that heated zone. Heat treatment of straight chrome steels after welding is usually required. Most practical combinations other than 18-8 to 18-8 with an 18-8 rod require special consideration.

Castings of 4 to 7, 11 to 13 and 16 to 18 chrome steel, as well as 18-8, 25-12, 26-20, and other nickel-chromium alloys, may each be welded by rods of their own analysis, before heat-treatment. The weld becomes an integral part, of like behavior, and has no real difference in corrosion rate, physical qualities or machinability.

18-8 rod welded as a single layer onto ordinary steels produces a layer of about 12% chromium, 5% nickel. This alloy has corrosion and abrasion resistance, not equal to 18-8 but often entirely satisfactory. The layer, if thin, will break when the piece is bent. If extraordinarily heavy, apparent ductility may be present. A single thin layer will machine readily only when the parent metal is fairly low in carbon and free of tungsten and certain other elements.



Microphotograph of Weld in 18-8 Stainless Steel.

(Weld metal at the left and parent metal at the right, with junction between. The weld is a good casting, cleanly joined to rolled metal which secured its crystal structure in the rolling process. The crystals in the parent metal near the weld have grown due to the heat of welding. This band along the weld will resist corrosion only when it has a low carbon content. Magnified 150 times, and reduced one-half in reproduction.)

18-chrome-steel rod welded as a single layer onto ordinary steel is hard, requiring grinding. The corrosion-resisting quality of this layer will compare favorably or unfavorably with that from 18-8 rod, depending on the corroding liquid.

25-chromium 12-nickel rod welded onto ordinary steel has all the qualities after welding of 18-8. It is readily machinable, ductile and has the corrosion-resisting qualities of 18-8.

Properties and Cost of Overlay Deposits

The hardness of overlay deposits depends on the carbon and alloy content of the parent metal. Abrasion-resisting qualities may be better or worse than that of the alloy rod. Abrasion-resisting qualities of 18-8 weld metal are better than those of 18-8 rolled steel.

Overlays of 18-8 or 18-chrome-steel rod on ordinary steels are common. The cost of such layers being between $5 and $15 per sq. ft., their use is highly desirable for complete linings of large, heavy castings and forgings, covering exposed surfaces, and for isolated portions of large castings subject to corrosive agents.

Overlays and linings of 25-chromium 12-nickel rod inside heavy tubes, connections and fittings of ordinary steel produce 18-8 results in these when hooking all 18-8 accessories up to them.

A stainless weld must make a continuous surface, have strength, and resist corrosion. Welding manipulation is almost entirely responsible for physical shape and may be responsible for slag inclusions, surface pin-holes and worm-holes. The rod and its coating are primarily responsible for the strength and acid-resistance. Penetration is inherently different among different coatings, but is still very much under control of the operator.

Need for Controlling Arc Length

Surface pin-holes come from a long arc. The welder can control the length of the arc, like holding a pencil near a sheet of paper. The characteristics of the current from the generator determine the minimum arc length that the welder can hold without short-circuiting. The characteristics of the current are right when the short-circuit is easily broken by pulling back the rod, and wrong when the short-circuit requires pulling the rod back 1/16 or ⅛ in. before the molten connecting metal breaks.

The voltmeter gives an exact measure of the length of the arc for any given rod. The proper voltage for most stainless rods is 20 to 30, while 35 volts is the very maximum that will produce good welds.

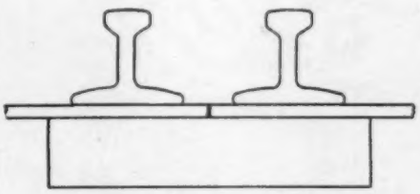
Worm-holes inside the weld are thought to be the fault of the rod coating. Weaving or changing to a larger-diameter rod with the same current may help.

Stainless rods are usually operated "positive.". Dependent on the coating of any particular rod, negative operation is sometimes helpful. In position work, the rod should be positive, with welding upwards.

The ultimate strength of a good 18-8 weld is between 75,000 and 95,000 lb. per sq. in. The yield point is between 20,000 and 45,000 lb. per sq. in. Elongation is about 30%. A wrinkled or alligator skin will appear on the tensile specimens.

The Bend Test and Its Value

The bend test is of real value. A weld between two plates or sheets is ground off flush and bent over in a vise. The center line of the weld is held just at



Clamping Stainless-Steel Sheets for Welding.

(All the essentials of clamping are shown in this diagram. The rails hold the sheets firmly and remove considerable heat. Heat is also removed by the bottom block. Only ordinary care is needed to prevent welding to the bottom block. One I-beam for the bottom and two long pieces of 1x3-in. bar steel are more convenient. Rails and bars should be straight as possible. Tacking should be used with this set-up.)

the top edge of the vise. The metal will bend down to a sharp right angle and may or may not bend flat on itself. Bending around a mandrel twice the thickness of the plate is more common practice, but requires considerable care to insure of the weld's being bent. This test requires 180° without fracture. Fracture at the line of fusion between parent and weld metal opens the welding technique to question. Bending across an unground weld is a useful and rapid means of test but is only surely indicative of soundness and freedom from holes.

The physical apearance of the back side of the welds is a good means of judging the operator but not the rod. Clamping changes this picture, but only to the extent of altering the regulation and method to produce the reverse side desired. Height, width and regularity of the bead, front or back, and penetration, are all at the control of the operator. Ripple marks are meaningless, possibly characteristic of rods of high inherent penetration. Lack of penetration just at the ends of the tacks is prevented by the method of approaching the tacks and by changing the character of the tacks themselves.

Cracks lengthwise of a weld are proof of puddling. They usually result from trying to make one pass do the work of two. Either a lower current or a larger rod at the same current are indicated. Cross cracks are of more complicated origin but are prevented by the same technique. Puddling must be avoided at all times. The long crack being definite evidence of puddling, is a phenomenon of hot-short metal. Analysis shows little of value as to the cause, but the cause has been definitely established as too long an exposure of metal to or in the direct arc stream. Puddling may creep in unnoticed in deep vees, fillets and plug holes. The cracked metal resulting is still corrosion resistant but useless as a weld.

Testing for Resistance to Corrosion

Weld metal judged to be good by these tests is most apt to be good metal for corrosion resistance. Subjected to corrosive liquids, it should resist almost as well as the sheet of the same analysis. Tests of any certain stainless alloy against any particular corroding liquid should be made unless that special combination is one of the growing list of known action. These tests should include tests of welded specimens. Welded samples should be large enough to include some unheated sheet.

Serious errors arise in corrosion-test specimens due to non-removal of slag and burred edges. Slag should be completely removed, the samples passivated and recleaning of slag be performed if any is present. Any second chipping of slag or filling of edges should be followed by a second passivation.

Carbon in the weld is usually reported as 0.05% to 0.11%. Correct carbon analysis is unusually difficult, and samples of known carbon content should be analyzed at the same time for a corrective factor. There does not seem to be any noticeable difference in corrosion resistance of welds of from 0.05% to 0.10% carbon. The strength of the welds does not differ materially if the carbon is within these limits.

Sheets May Be Butted Tightly for Welding

The closure ahead of welds in stainless sheet is absolutely undependable, and none is used. Thin sheet, up to 18 gauge, clamped always, is butted tightly without any opening. 18 and 16 gauge clamped may be butted tightly, in which case ⅛-in. rod may be used. 18 gauge not clamped should be butted tightly, tacked freely and welded with 3/32-in. rod. 16 gauge not clamped may be butted tightly or left with an opening of about 1/32 in. The heavier gauges

are opened or butted tightly as in mild-steel practice. Scarfing is not necessary on 10 gauge, but a larger-diameter rod should be used if not scarfed than if scarfed. 3/16-in. plate should be scarfed to within 1/16 in. of the bottom.

The securing of full penetration in stainless steel is dependent on rod size more than in working with ordinary steel. Tightly butted edges consequently are best handled with the use of larger rods. These figures are only rough approximations:

Sheet, Gauge	Rod, Diameter	Amperage
20 to 14	1/16 in.	70 to 100
16 to 10	1/8 in.	80 to 130
12 to 1/8 in.	5/32 in.	100 to 160
1/8 in. and up	3/16 in.	125 to 200

Consistent results are only obtained by operation of any given size of rod within the actual range of current in which it performs properly, and a change of rod size is indicated by need of greater or less penetration.

Tacking the Work Before Welding

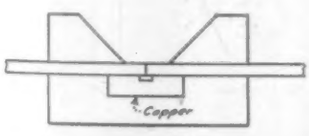
Tacks should be made with as full penetration as finally desired in the weld. As they are to be welded over, they should be long, not high, and in general are better if made with greater current than is suitable for the weld. Tack 18 gauge at 2 to 4 in. intervals; 14 gauge, 3 to 6 in., and 10 gauge, 3 to 9 in., for open welding.

Clean all slag from the tacks before welding. Do not hammer them, as that will separate the edges of the sheet.

Following tacking, sight down the sheet and feel with the fingers, correcting any misalignment before welding.

Bumps or high places at tacks and in the junction of steps or back steps are prevented purely by manipulation.

Weaving over the top of the tacks is usually best when the tack is encountered in the middle of a section—that is, when both rod and sheet are hot as welding with the rod proceeds. When starting a fresh rod, either at a tack or at the start of a previous section, it is



Using a Copper Bar for Backing-Up.
(The copper should preferably be a single bar of about ¼x¾ in., inserted in a bottom block of steel or cast iron. It must be milled out directly under the weld to prevent it from removing heat too rapidly. The width of the milled slot is important, as it fixes the width of the back side of the finished bend; it should be about 1/8 in. wide for 18 to 14 gauge sheet.)

better to strike the arc at a small distance back in the unwelded section, either welding into the tack and then setting out in the original direction desired, or merely heating by a rather rapid passage of the arc with welding starting on the tack. Puddling or holding the arc at one place to secure penetration is never permissible.

Clamping Removes Heat Rapidly and Prevents Buckling

Clamping is meant to refer to clamps, backing bars, jigs and fixtures. The main purpose is usually the perfect alignment and positioning of edges, but big advantages lie in the faster heat removal. Most important is the elimination of buckling, which can be very serious in stainless steel because of its 30% greater expansion and contraction compared to ordinary steel. Altogether the heat effects of welding are about three times as severe as on ordinary steel because of this greater expansion and because the stainless sheet conducts heat away from the weld only half as fast as steel.

Welders understand the high expansion rate because of the practical impossibility of making correct closure ahead of a welding seam. Buckles which develop alongside of seams open welded, are a direct result of uneven expansion and later contraction. With the work clamped, the strain introduced is restricted to a small area of the sheet and to the weld. This little area of free sheet has practically no chance to move and, being relatively a stronger structure, would require a much higher stress to buckle it. Hence, nearly all expansion and contraction of a clamped job is in the soft, plastic weld metal. The low locked-up stress which remains is of no consequence except in pressure vessels.

The low heat conductivity is apparent in the quick melting and running away of the molten metal, which follows rapidly after arcing onto thin stainless. That action taking place as soon as it does, limits welding of thin sheet by requiring the use of low current and high forward speed. Open or unclamped or unbacked work becomes very difficult, neither man nor machine being suited for it. Clamping and backing bars remove this heat more rapidly, and the forward speed and generator settings are within workable ranges to produce good welds.

The chief troubles are caused by bending of clamping and backing bars. They should be as rugged as possible, but still give a free opening for the rod, wire brush and chisel. Sheets of 12 gauge and thicker are often welded without clamping. Tacks are advisable on long seams unless the clamping bars are extra strong, true and tight. Backsteps or variations suited to the exact conditions are advisable.

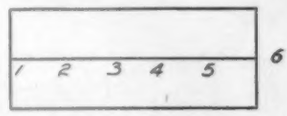
Copper is better for heat removal; and as it is very unlikely to be spoiled by welding adhering to it, it should be used in any prepared clamping arrangement.

In welding a square tank, it may be assembled by tacking the corners, after which a copper bar can be braced into the corner.

As far as is known today, there is no practical limit to gauges which can be welded by the aid of correct clamping, except the skill of the operator. 20 gauge is very difficult, and 18 is the thinnest that can be handled by most welders.

Back-Step Method Reduces Distortion

The back-step method of welding should be used on all heavy stainless work. Light work has least distortion when it is used. It leaves less locked-up strains in the weld. The length of



Illustrating Back-Step Method of Welding.
(In welding a straight seam as shown, the back-step method means welding from point 3 to 2, then 4 to 3, then 5 to 4. Some variation is often needed, as for example at the ends of the seam. In light work, it is hard to finish full by welding out to an edge—as the step-back method would indicate here by welding from 2 to 1. In either light or heavy work where another plate crosses at 6, it may be better to finish by welding from 5 to 6. Heavy plate and a small rod might best be handled by welding from 2 to 1 and from 5 toward 6. Skipping from a hot to a cold section is sometimes of value.)

section welded at any one time can be, say, half a rod consumption, or from tack to tack, or a third the length of a short seam, etc. The residual stress is lower with shorter sections.

Buckles and waves appear in thin stainless-covered fountains and bars, mainly because the metal has been stretched in places. A minor cause is excess metal due to over-allowances.

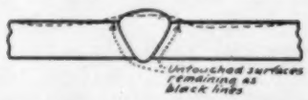
Preventing Buckles and Waves in Stainless Sheet

Prevention includes avoidance of some common methods of working which were all right for ordinary steel. Hard heels tramping on stainless steel can leave large, distinct buckles, in addition to scratches. Picking up a sheet at one end, twisting it to stand on edge, and dropping it, can easily be responsible for queer light reflections in the finished job. A large sheet being worked at one end while the other waggles in the breeze has a big strain at some point where it is being held. In each of these and many other operations, local areas are stretched while they still remain surrounded by unstretched, shorter metal. Summed up, the thin, annealed, polished sheet is in danger of dents, bends, stretching and scratching in every operation. Definite points to be watched are: handling; matching of holes by drifting; clamping to tables of machines and to the assembled structure; method

of supporting; dropping articles on it; and grinding.

Prevention depends also on such things as straight seams being straight. The welder can readily pull together two edges which were sheared curved, in such a manner as to leave large buckles. This is the more apt to happen as he improves his welding technique. Grinding may also produce more and more buckles as the grinder becomes more confident and he bears heavier. Misalignment and off-angles bring out waves. Wood screws over-tightened can pull the stainless steel into little pockets; one screw on an edge may pull the top of a table down tight while the very next may leave the metal completely out of contact. Enclosure of an 18-in. top of a table with stainless steel which has been broken to 18⅛-in. size is sure-fire trouble.

Poor light reflections on a finished job do not appeal much to the customer. The



Effect of Grinding Across the Bead.
(Note the untouched spaces at the edges of the weld and the reduction of the gauge beyond these areas.)

premium he pays for beauty imposes the need for prevention of buckles. The good workmen who give painstaking attention after it is all explained to them, certainly deserve to have the work minutely inspected by the foreman before and after each operation.

Worked or Welded Metal Should Be Passivated

Passivation is always required on welded and worked surfaces. The stainless surface is truly rust-resistant after passivating has filmed the surface in general and has especially removed the tiny particles of weld spatter, steel particles from wire brushes, shears and all conceivable sort of foreign material from the worked surfaces.

The passivating liquid is 20% nitric acid in water. It is effective lukewarm. The time may be several minutes. The action is visible in producing at first a thin, black film over the surface. Gentle rubbing with a brush or cloth removes this. No further formation is taken as completion of passivating.

The acid is made and stored in crocks or water bottles. Completed tanks do not require complete filling, but can be rolled to slosh the acid around. Large work can be swabbed. The action should be all over the complete surface.

Washing afterwards is best with warm water. The work should not be swabbed or rubbed after the acid is drained or in this washing.

Two precautions are needed in grinding welds:

First, thin sheet should be supported in back of the place being finished. This keeps from introducing waves and buckles when the pressure from the wheel is at all heavy. Frequent wheel dressing prevents the hammering of an eccentric wheel and is of genuine value in the speed of grinding.

Grinding Should Be Parallel to the Seam

Second, grinding crosswise of the seam is rarely defensible. Two serious consequences of grinding across the bead are the leaving of completely untouched spaces just at the edge of the bead, and reduction of the gauge by the grinding at some distance each side of the weld. Grinding with the wheel in a plane with the weld has only one small fault—a slightly thicker section along the center line of the weld. The dotted line in the diagram indicates the surface crosswise grinding brings about.

Flexible-shaft grinders use about 80 to 120 grit wheels of alumina with vitrified bond.

Polishing wheels are run with or across the welds. Coarse emery marks in one direction are all removed with the next finer bob in the cross direction. These emery bobs are of canvas, rolled in a shallow saucer or pan of hot glue, then turned through loose emery.

Book Reviews

METALLIC ARC WELDING. By H. Harris. 6x9 in.; 199 pages; 99 figures and many tables. Cloth binding; price, $6.00. Published by Longmans, Green & Co., 114 Fifth Ave., New York, N. Y.

As a reference work on the metallurgical aspects of arc welding, this book fills a definite need among welding literature. Equipment, materials and technique are dealt with only to the extent that they are necessary in any treatment of weld metallurgy. Besides mild steel, the author also takes up the metallic-arc welding of structural alloy steels, 18-8 stainless steels, austenitic manganese steels, copper and its alloys, and nickel and monel metal. Chapters are also devoted to the application of the process to pressure vessels and the chemical industry, boiler drums, pipe manufacture, ship construction, and miscellaneous structures.

The author confines his observations largely to English and American practice. He has brought together a great amount of very valuable data of recent origin.

THE WORKING, HEAT-TREATING AND WELDING OF STEEL. By H. L. Campbell. 6x9 in.; 185 pages; 94 figures and 10 tables. Cloth binding; price, $2.25. Published by John Wiley & Sons, Inc., 440 Fourth Ave., New York, N. Y.

The student wishing to obtain a knowledge of the making, working, and heat-treating of steel will find this textbook a great help for acquiring the elements underlying the subject. After studying this text, he should be able to digest some of the more advanced technical literature.

The book begins with the manufacture of wrought iron and steel and the casting of ingots, followed by an explanation of the effect of the various chemical elements on the physical properties of steel. The various classifications of steel are then discussed, and methods for obtaining physical tests are described. Photomicrographs and grain-size diagrams are included in a chapter on temperature changes and mechanical working, and processes for working steel are described at some length. The reader will find the chapter on the physical constitution of steels very easy to grasp. Considerable information is given on heat-treatment of carbon and alloy steels. The chapter on welding is too brief for the material to be presented in any other than a sketchy manner, and the illustrations might be brought more up-to-date. The preservation of steel by coatings and by the formation of corrosion-resisting compounds is also discussed.

Each of the 12 chapters is followed by review questions, and 18 practical laboratory assignments are included, these pertaining to heat-treatment, testing, forging and welding.

THE RELATIVE RIGIDITY OF WELDED AND RIVETED CONNECTIONS. By C. R. Young and K. B. Jackson. 6¾x10 in.; 134 pages; 35 figures and 6 tables. Published by the National Research Council of Canada, Ottawa, Canada.

Using 9-in. 20½-lb. Bethlehem-beam double-cantilever specimens with 5 types of welded connections to study beam continuity, and 18-in. 47-lb. Carnegie-beam double-cantilever specimens with three types of riveted or welded connections, primarily for the study of wind-bracing rigidity, the authors evolve certain conclusions regarding design of joints for maximum restraint. Some of these results may be summarized as follows:

Welded connections as ordinarily designed for end restraint fall short of the ideal value of 0.75 for the coefficient of

restraint by from 10% to 25%. This ideal value (for gravity loads only) is exceeded, however, in the case of both riveted and welded connections designed for capacity wind movement. Where T's are welded or riveted to a column flange for connection to the top and bottom flanges of the beam, welded connections give rise to much less lineal drift under a capacity wind in one direction than riveted connections, and the least drift is shown in the case of welded gussets. From a third to a half of the flexural slope in a wind connection to an unstayed column flange may be charged to the deformation of the column flange, and welded connections are definitely stiffer than riveted ones, at all points. For the riveted T-connections, a large part of the longitudinal deformation was non-elastic slip, this accounting for 31% in the case of a connection to a column web and 46% with the connection made to the column flange. Welding of stiffeners to the column flanges reduced the longitudinal deformation of the welded T and the welded gusset connections to 75% and 85%, respectively, of their former values. The ratios of the test factor of safety to the design factor of safety showed a wide variation. It is concluded that non-uniformity of stress, which apparently existed to a marked degree in the welded T-connection specimens, may cause the capacity of certain types of connections to fall considerably below that estimated on the basis of uniform distribution.

THE BOOK OF STAINLESS STEELS. Edited by Ernest E. Thum. Second edition; 6x9 in.; 787 pages; 292 illustrations and many tables. Cloth binding; price, $5.00. Published by The American Society for Metals, Cleveland, Ohio.

Since its first edition, published only two years ago, this book has taken forefront rank as a reference work on stainless steels. Its chapters were written by 75 authorities, each contributing to the subject such information as pertains to his specialized field. Though the book deals chiefly with chromium and chromium-nickel steels, all "stainless steels" come in for discussion. Constitution of these steels, their production and fabrication, properties, testing, and requirements of consuming industries, are taken up at length. A wealth of information is given on welding procedure, tests, and inhibition of intergranular corrosion.

Several chapters in this edition are new, and a number of others contain data not given in the former edition. In the section on welding, new data are given on the arc welding of 18-8 steels and a chapter is included for the first time on arc welding high-chromium irons. The effect of columbium additions to stainless steels to minimize surface corrosion or intergranular corrosion is given for the first time. Other chapters not included in the first edition pertain to the 29%-chromium-19%-nickel alloy, thermocouple alloys, illium, and requirements of railroad rolling stock. Chapters on resistance to scaling, and requirements of the petroleum industries, have been entirely rewritten. New data are also given on the effect of composition and heat-treatment on the properties of 18-8 alloys. In the classification of trade names, actual chemical limits are included for the first time. A comprehensive index increases the value of the book as a reference work.

THE PHYSICAL CHEMISTRY OF STEEL MAKING. By C. H. Herty, Jr., and associates. 6x9 in.; 350 pages; 116 figures and 63 tables. Cloth binding; price, $3.00. Published by the Mining and Metallurgical Advisory Boards, Carnegie Institute of Technology, Pittsburgh, Pa.

This book comprises reprints of six recently published bulletins on research conducted during the past eight years. These pertain to such subjects as the specific reactivity of various oxidizers and grain-size effect on ferrite formation in plain carbon steels, the effect of manganese, silicon and aluminum on grain size and grain growth, effect of deoxidation on quench aging and strain aging of low-carbon steels and on impact strength at low temperatures, development of open-hearth control methods on 0.06% and 0.60-0.80% carbon steels, and a review of the entire experimental work on deoxidation.

BIBLIOGRAPHY OF NON-METALLIC INCLUSIONS IN IRON AND STEEL. Compiled by Lois F. McCombs and Morris Schrero. Cooperative Bulletin 70, Mining and Metallurgical Advisory Boards; 6x9 in.; 308 pages. Cloth binding; price, $4.00. Published by the Mining and Metallurgical Advisory Boards, Carnegie Institute of Technology, Pittsburgh, Pa.

This bibliography is arranged alphabetically by authors. It contains 2,136 items with many additional references to reprints, translations and abstracts. The brief annotations do not attempt the function of abstracts, but they are intended to help the user of the bibliography to decide whether it is worth while for him to consult the original. A subject index contains 1,338 entries with references, by number, to the author index.

A STUDY OF THE FORMATION OF IRON NITRIDES BY FUSION AND OF THE NITROGEN-IRON SYSTEM. (In French.) By D. Saferian. 6 x 9¼ in.; 101 pages; 52 figures and many tables. Paper binding; price, 20 francs. Published by Institut de Soudure Autogene, 32 Boul. de la Chapelle, Paris, France.

This book reports the results of research made in the laboratories of the Institute of Autogenous Welding on the absorption of nitrogen at the time of the fusion of the iron by the different welding processes. The author studies in particular the mechanism of the formation of iron nitride by fusion, by the spectrographic method, and brings to light the existence of the atomic form of nitrogen in the arc.

The study by thermo-phyical methods of the samples nitrided by fusion leads to the establishment of a new nitrogen-iron diagram. The author also discusses the effect of nitrogen on the aging of iron and the welding of steel.

FINANCIAL INCENTIVES: A Study of Methods for Stimulating Achievement in Industry. 6x9 in.; 47 pages; 14 tables. Paper binding; price, $1.50. Published by the National Industrial Conference Board, Inc., 247 Park Ave., New York, N. Y.

This is a study of the experience of industrial concerns in operating incentive wage systems under present-day conditions. Modification of systems, brought about by recent conditions, and the probable future role of incentives in American industry, are given consideration. The final paragraph states: "The fact that incentive systems have, in most cases, survived so protracted a period of severe curtailment of manufacturing activity indicates that they have served a useful purpose. Their continued use for the objectives which they are intended to achieve seems likely."

WANTED: SKILLED LABOR. 6x9 in.; 37 pages; 4 tables. Paper binding; price, $1.00. Published by the National Industrial Conference Board, Inc., 247 Park Ave., New York, N. Y.

According to reports from 287 companies manufacturing metal products, which employ in the aggregate 115,260 wage earners, 1,193 skilled craftsmen could be given employment today by these companies if they were available. If these companies were operating at what they consider normal capacity, 7,767 skilled mechanical workers would be needed. These are some of the surprising statements found in this booklet. Occupants for which there appears to be the greatest need are tool- and die-makers, all-around machinists, special-machine-tool operators, and moulders. Enough applicants cannot be found who can really qualify for these positions. If this condition is prevalent throughout the entirely metal-working industry, then there is a total present shortage of 19,034 skilled machinists. Probable reasons for this shortage are given, together with suggested remedies. Tables based on a survey give the skilled-labor shortage by states, and list the occupations in which a shortage is reported.

East Grand Rapids Belt Grade Separation . . . .

■ By L. W. MILLARD
Bridge Engineer, Michigan State Highway Dept.

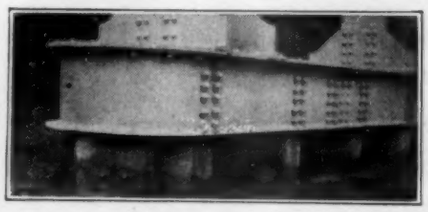
AN ESSENTIALLY all-steel grade separation in which both welding and riveting were used has been built over the Grand Trunk Western Railroad at its intersection with the East Grand Rapids (Mich.) Belt Highway (M114). This structure consists of two approach spans of 26 ft. 10¾ in. and a center span of 48 ft. 8½ in., with a 42-ft. clear roadway and 2-ft. 6-in. safety walks. While the structure at present crosses only one track, the center-span opening was designed to permit the future addition of two more tracks. The design also provides for ultimately lowering the tracks 8 ft. 6 in.

Sheet Piling Used for Abutments and Piers

Copper-bearing-steel sheet pile were used for abutments and piers, consisting of 5x16-in. arch web sheeting weighing 25 lb. per sq. ft. Sheet piling was ordered in 35-ft. lengths for the abutments and 32-ft. lengths for the piers, based on boring information, which indicated an underlying clay soil, and on data obtained by driving angle test piles. Cut-off on the piles averaged 2 ft., and the calculated bearing capacity per pile was approximately 20 tons. Timber guide piles and 10x10-in. guide waling were required to obtain proper alignment, a maximum tolerance of 1 in. being permitted. A 3200-lb. drop hammer was used and no unusual difficulties were encountered in the driving. The interlocks of all piling were welded together with a ⅜-in. continuous weld on each side for a length of 18 in. below the cut-off.

The abutments were built with a single line of sheeting. The piling beyond the edges of the superstructure was turned back through a circular arc to form the wing walls. All piling in the abutments was cut off at bridge-seat elevation. The abutment bridge seat consists of a steel plate mounted on a pair of angles capping the steel sheet piling. The angles were attached to the sheeting by fillet welding along the lower edge of the vertical legs across the webs of the piles and welding between the tops of the piles and the horizontal legs of the angles to provide bearing. The 12x ½-in. steel plate forming the bridge seat was then plug welded on top of the angles. Bolster blocks for supporting the floor stringers were then fillet welded to the bridge seat.

The Pier Bents Are of the Column-and-Girder Type, With Cap Plates Welded to the Top of the Columns.



View of Pier Nose, Showing Channels Bolted to Piling, the Interlocks of Which Are Welded Together.

The backwall was formed by fillet welding 34x½-in. plates to the back of the bolster blocks, the lower edge of the plates resting on the top of the angles capping the piles. The backwall was stiffened by angles fillet welded to the back of the plates and to the angles capping the piling. 8x½-in. plates were fillet welded to the top of these stiffener angles to form the pavement seat. Sloping backwall wings were constructed of curved ½-in. plates, fillet welded to vertical stiffening angles which were in turn welded to the angles capping the piling. A concrete cap 1 ft. 3 in. high by 8 in. thick was cast along the top of the backwall wings for the sake of appearance.

The piers were built with two parallel lines of steel sheet piling cut off approximately 4 ft. above the proposed top of the railroad tracks and filled with concrete to a depth of 6 ft. below the cut-off to act as a collision wall. The piling was capped with ½-in. plate bolted to 15-in. channels, which were in turn bolted to the outside of the steel sheet piling. All holes for attaching the channels to the piling were field drilled. The pier bents above the sheet pile cap were of the usual column-and-girder type, all connections being riveted except the ¾-in. cap plates, which were shop welded to the top of the columns.

Flooring Welded to I-Beam Stringers

The superstructure, of the steel deck girder type, is composed of I-beam

View of Completed Steel Overpass.

Wing Wall at North Abutment.

View of Wing Wall, Showing Piling Capped by Angle.

stringers on which ribbed steel flooring is laid. The flooring, laid with ribs running transverse to the roadway, was manufactured by pressing ¼-in. plate into alternating ribs and troughs 3 in. high by 4½ in. wide with ⅜-in. by 2⅜-in. bars run through slots cut in the flooring at third points of the spans and welded in place. The flooring was attached to the bridge by plug welding to the I-beam stringers. I-beams were framed between the stringers at the ends of the bridge to support the skewed ends of the flooring. Steel plates were welded around the edges of the flooring to retain the asphalt surfacing. The safety walks consist of ¼-in. floor plate carried on angle and channel stringers, which are supported by brackets cantilevered from the outside floor stringers. The steel railing was fabricated from standard structural shapes. Most of the connections in the railing and safety walks were riveted. The roadway flooring was filled with a bituminous mixture to the top of the trough sections and a rock asphalt wearing surface provided.

Welding Operators Required to Pass Qualifying Tests

All welding operators were required to qualify by making test welds. Flux-coated electrodes were used.

The total contract cost of this structure was $24,715.89, or $5.75 per sq. ft. of roadway. Work was started Aug. 22, 1933, and completed, except for grading and clean up, Dec. 23, 1933.

A recent inspection fails to show any signs of deterioration except for a few rust spots over the welds which apparently were not properly painted. Because of the difficulty of driving the piling in the abutments exactly to line, construction might have been facilitated by using heavier angles or possibly channels for capping the sheeting. The sheeting then could have been drawn to better alignment by bolting the cap angle or channel to the top of the sheeting.

This structure was built with funds furnished by the Federal Government under the supervision of Murray D. Van Wagoner, State Highway Commissioner.

The Peninsular Construction Co., of Grand Rapids, Mich., were the general contractors on this project. Structural steel was furnished by the R. C. Mahon Co., of Detroit, and the ribbed steel flooring by the A. O. Smith Corp., of Milwaukee, Wis.

Receives Contract for Laundering Machine

The Steel City Welding Shop, 507 Market St., Youngstown, Ohio, has received a contract for the construction of a new washer 48 in. in diameter and 60 in. long, for the Overall Supply Co., of Youngstown. The machine is to be used for washing overalls.

The washing unit is made up entirely of steel in cylinder shape, all joints being welded from the inside. The base is of a standard type and is designed for bolting to the floor. L. Schlabaugh, manager of the Steel City Welding Shop, expects a lot of this kind of work this summer. The shop has just purchased a new portable arc-welding machine, and the concern is going after all the contract work in sight.

Welded Ornamental Arch-Way Is Artistic Job

By W. E. ARCHER

An all-welded ornamental-iron arch has been fabricated for the United States Marine Base entrance at San Diego, Calif. Into this artistic work went about 750 different pieces of material, composed of scrolls, twisted and open steel bars, angles, etc.

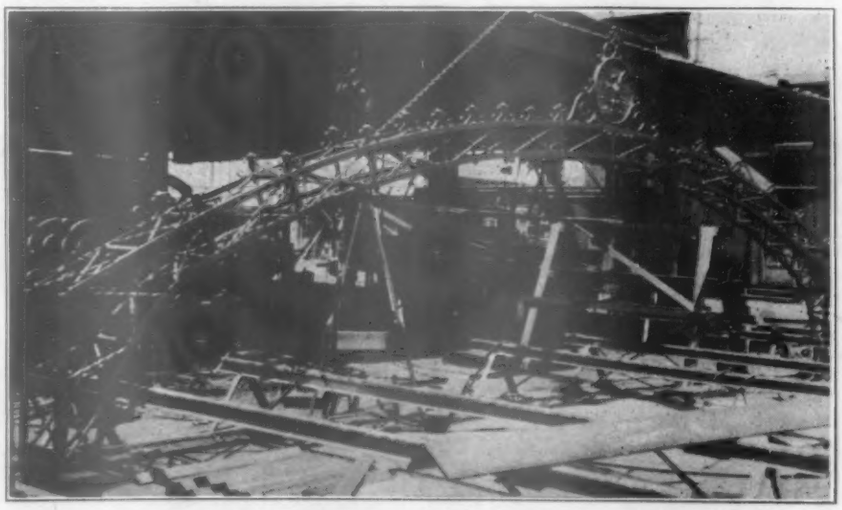
The arch is 34 ft. long. The frame ranges in size from 12x16 in. in the center to somewhat larger dimensions toward each end, as noted in the illustration. It is one of the largest pieces of all-welded ornamental-iron work ever constructed in southern California, and the first contract of its kind ever awarded by the Navy Department, specifying, as it did, all-welded construction. Approximately 2,500 welds went into its fabrication, and 3/16-in. mild-steel bare electrodes were used predominantly on the job.

The longitudinal members of the main frame of the arch are of 2x2x¼-in. angle iron, cold rolled to shape, while 1½x1½x ¼-in. angles are used for the vertical members of the frame. Twisted ¾-in. square steel bars form the diagonal pieces between the vertical angles, while the scrolls on the top are made up of ⅜x1¼-in. bars welded to uprights of 1¼-in.-square bars.

In welding the twisted diagonal bars, first one bar was welded in place, and then the other one was cut in half with the cutting torch and the ends flattened for a more smooth and artistic joint at the point of crossing, where the ends were welded to the first twisted bar.

A beautifully designed finial bronze plaque, 24 in. in diameter and weighing 160 lb., is shown in place over the center of the arch. The only exception to the all-welded construction of the arch is the method used in securing the scrolls supporting the bronze plaque. This was done by bolting.

The contract for the construction of this interesting piece of ornamental-iron work was awarded to the Standard Iron Works, of San Diego. The welding was done practically in its entirety by M. Kelly, to whom much credit is due for the fine quality of workmanship displayed in this artistic job.



34-Ft. Arch, Having All Elements Assembled by Welding.

Weld Metal and Rolled Steel ...

How Do They Work Together?

■ By RIDDERVOLD JENSEN
Naval Architect and Welding Engineer

THE electric-arc and gas welding processes provide means of assembling different parts into a monolithic structure. Any filler metal added to form the weld is joined with the parent metal through fusion, thus making a most rigid connection. This implies, however, that the weld itself is forced to an intimate cooperation with the parent metal, and the problem of how the two metals, which may have different physical characteristics, will behave when the structure is loaded will have to be considered.

Perpendicular and Longitudinal Stresses Are Considered Separately

The stresses to be met jointly by the two materials are those set up when *making the weld* (shrinkage stresses) as well as those caused by *external loading*. In analyzing the problem it is convenient to consider, at first separately, the forces acting perpendicular to the joint and those acting longitudinal to the joint. Also, for simplicity, we will retain the mental picture of a butt weld in a big plate.

To resist forces acting *perpendicular to the joint* we are able to make the finished weld itself the strongest link in the chain by applying a full section area of weld metal with high yield point and tensile strength. Should such a weld be exposed to perpendicular forces—caused by shrinkage or external loading—exceeding the yield point of the plate material, then the plate will elongate by yielding on both sides of the joint, whereas the weld itself will be relatively unaffected. The ductility of the weld metal will therefore be of secondary importance. On the other hand, when building up with multiple layers, the shrinkage strains will concentrate on the small section of the unfinished weld, and the ductility of the weld metal must be high enough to withstand the deformations which may result. In both cases, however, a high yield point of the weld metal is favorable, as thereby the deformations are as far as possible conveyed to the parent metal. (When welding a parent metal of very low ductility, such as cast iron, the conditions are different. The ideal would then be a weld metal which would stretch like rubber, or one with a low yield point and excellent ductility to take care of shrinkages which in the cast iron itself would cause cracking.)

EDITOR'S NOTE: Mr. Jensen's two articles on "Shrinkage Strains and Stresses Caused by Welding," which appeared in the February and March, 1935, issues of *The Welding Engineer*, created great wide-spread interest, and we are pleased to publish herewith another contribution from this author. The following synopsis is given of Mr. Jensen's life and activities:

Born, in 1901, in Toensberg, Norway. Present address: Weidmannsvei 19, Trondheim, Norway.

Education: "Dipl.-Ing." degree of Naval Architecture and Marine Engineering from the Norwegian Institute of Technology, Trondheim.

Engineering experience: Formerly instructor in naval architecture, and on engine-room staff of motorships. Four years in the Estimating and Scientific Department of the Sun Shipbuilding & Drydock Co., and later with the Nakskov Skibsvaerft, Denmark.

Welding: Received in 1931 a grant from The Norwegian Shipowners Association and also from the Norwegian Institute of Technology, and made a detailed study of the problems of welding as applied to shipbuilding. Spent some time abroad, mostly in Germany, at welding schools and institutions and visiting welding firms and shipyards.

Present position: Assistant to Dr.-Ing. N. Lefring, Norwegian Institute of Technology, on welding research work.

Special welding activities: Has presented papers on welding before the Norwegian Welding Society, Oslo, the Society of Shipbuilders in Trondheim and Oslo, and the Engineering Society of Goeteborg, Sweden. Has lectured on welding at the Norwegian Institute of Technology and the trade school, Statens teknologiske Institutt, Oslo. Has published a 160-page report on "Welding as Applied to Shipbuilding" and papers in Norwegian trade journals.

On the other hand, weld metal, when stressed *longitudinal to the joint*, will of necessity always have to follow rather closely the deformations of the plate itself to avoid cracks and this is the case also when the yield point of the plate material is exceeded. During the welding, and when cooling down after welding, every weld, whatever its length, will be exposed to such stresses longitudinal to the joint, since shrinkage stresses develop which cause tensile stresses in the weld itself and compression stresses on either side.

To meet these longitudinal stresses, the ideal would be a weld metal of the same stress-strain characteristics as the parent metal itself. In particular, the yield point of the weld metal should not be essentially different from that of the parent metal, otherwise additional stress differences may develop when the two metals are jointly loaded. Such stress differences act to prevent the material from deforming naturally. As the multi-dimensional stress condition caused by the longitudinal and perpendicular shrinkage stresses also acts to the same end, the combined effect may be disastrous; this accounts for the sudden cracking without previous yielding in many welded parts, even when made up of otherwise ductile materials. While to avoid such risks the choice of correct welding procedure* is most important, the purpose of this paper is to investigate the strength properties of the weld metal, particularly in the neighborhood of the yield point, which have never, in the opinion of the writer, been given due attention.

Tests Made of All-Weld-Metal Specimens and of Steel Plate

Fifteen bars of all-weld-metal deposited by the electric arc and two bars of shipbuilding-quality plate, as recorded in the accompanying table, were tested. All the welded bars were produced by depositing layers, without weaving, in an angle bar, each layer being cool to the hand before depositing subsequent layers. Electrodes of 5/32 in. diameter were used, and welding was performed by an experienced operator, using direct current and 140 amperes for the bare electrode, 145 amperes for the coated, and 160 amperes for the heavy-covered.

The weld-metal bars were of 10-mm. diameter with a gauge length of five

*See "Shrinkage Strains and Stresses Caused by Welding," by Riddervold Jensen, *The Welding Engineer*, Feb. and March, 1935.

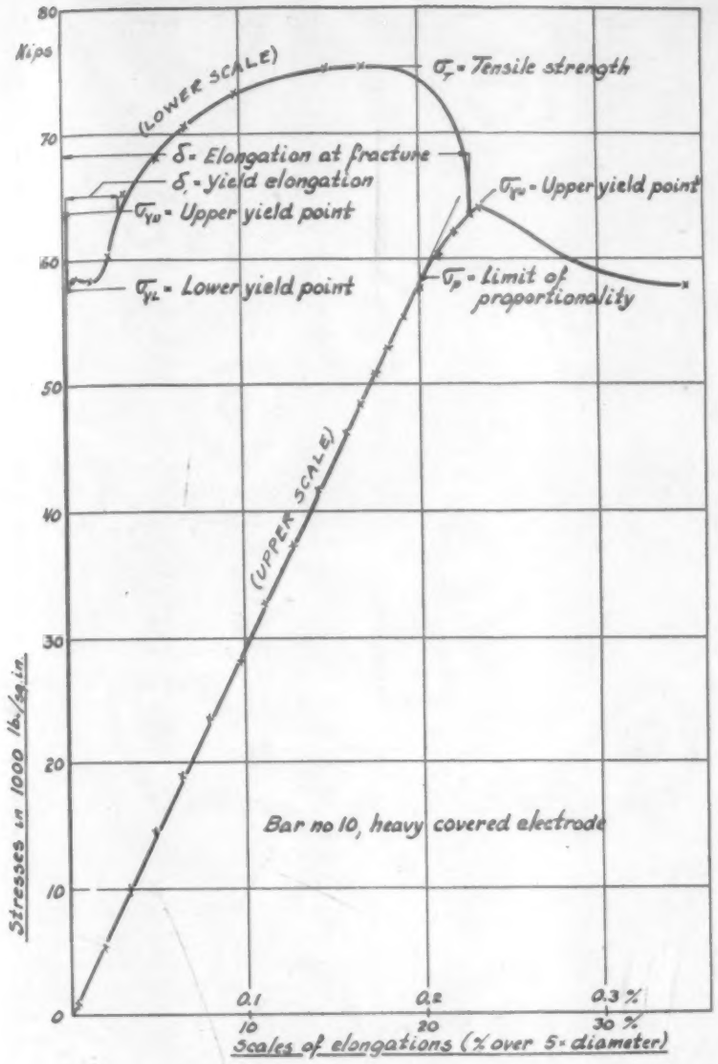


Fig. 1. Stress-Strain Diagrams of All-Weld-Metal Specimen Made with Heavy-Covered Electrode.

times the diameter. For strain measurements, two Roscher Lund extensiometers, one on each side of the test bars, were used; these allowed the taking of readings up to 2.6% elongation, and hence it was possible to follow the conditions around yielding most closely. At greater elongations than 2.6%, dividers were used for measuring between pairs of marks on both sides of the test bar. The bars were tested at room temperature (64° F.) in a Tinius-Olsen machine with spherical bearing of the grips and with a weighing beam. Measurements were taken at load intervals of about 4000 lb. per sq. in., which were reduced to 2000 lb. per sq. in. when the yield point was approached. Close to the yield point, the load was increased very slowly, and then the load was noted at which the beam more or less suddenly dropped; also the corresponding elongation was noted at which the extensiometers showed the start of a rapid elongation. This is the upper yield point σ_{YU}. After a pause, readings were taken at the load at which the beam again showed equilibrium. Then small steps of loading were made, and after each load the bar was allowed to stretch, after which readings were taken of the load and the elongation at the new state of equilibrium. The lower value of these loads is termed the lower yield point σ_{YL}.

Fig. 1 shows a stress-strain diagram for a test bar welded with a heavy-covered electrode. Here δ_1 denotes the percentage plastic elongation of the bar at the point where the load after yielding again has the same magnitude as σ_{YU}. Hence, δ_1 gives a measure of how pronounced the yielding, or permanent elongation, is at the yield point. Fig. 2 shows three diagrams for the three types of electrodes, two for annealed conditions, and one for shipbuilding-quality steel. In the accompanying table, the characteristic points in the diagrams of all the test bars are recorded, together with the mean value of each group.

The values in each test series are remarkably uniform. The surface of the fractures predominately showed the characteristics of ductile fracture with a dull-gray color; the exceptions were bars No. 2 and 5, in which 2/3 and 1/5, respectively, of the surface of fracture was crystal bright as a sign of brittle fracture. The fractures of the bars welded with bare electrode revealed some pores of a size up to 0.4 mm. diameter, the ones welded with coated electrodes some pores up to 0.7 mm. diameter, but the other bars were practically free from pores. In the case of bars No. 3 and 6, the fracture occurred outside the gauge length. The bars from shipbuilding-quality plate developed a tensile strength lower than that specified for such material (62 to 72 kips). An ultimate tensile strength of about 65,000 lb. per sq. in. should be used as the average for this material.

Comparative Properties Revealed By Test Specimens

The accompanying table reveals that the elastic modulus E for the weld metal

Strength Properties of Weld Metal and Ship-Quality Plate.

Type of Electrode	Bar No.	Proportional Limit σ_P kips	Upper Yield Point σ_{YU} kips	Lower Yield Point σ_{YL} kips	Ultimate Tensile Stgh. σ_T kips	σ_P / σ_T %	σ_{YU} / σ_T %	Yield Elongation δ_1 %	Fracture Elongation δ (5×dia) %	Contraction ψ %	Modulus of Elasticity E kips
Bare	1	39.0	50.0	48.1	68.5	58.2	72.8	0.7	14.8	20.2	28,200
	2	41.1	50.8	49.8	68.3	60.3	74.4	0.7	9.4	9.4	27,500
	3	38.6	50.5	48.7	67.5	57.3	74.7	0.7	(7.8)	(12.0)	27,000
	Av.	**39.6**	**50.4**	**48.8**	**68.0**	**58.6**	**74.0**	**0.7**	**12.1**	**14.7**	**27,600**
Coated	4	42.0	48.5	47.3	67.0	62.8	72.3	0.8	14.0	22.1	28,700
	5	42.0	50.0	48.5	65.8	64.0	76.0	0.8	10.0	15.7	29,100
	6	41.7	50.0	48.1	63.8	65.4	78.2	1.0	(5.6)	(9.3)	29,150
	Av.	**41.9**	**49.4**	**48.0**	**65.5**	**64.1**	**75.5**	**0.9**	**12.0**	**18.9**	**28,980**
Heavy covered	7	58.7	64.0	57.8	75.4	78.0	85.0	3.0	23.0	40.5	29,100
	8	55.3	61.2	56.2	73.8	75.0	83.2	2.8	23.6	48.5	28,750
	9	46.6	54.7	51.8	71.0	65.7	76.8	2.2	24.2	53.0	28,500
	Av.	**53.5**	**60.0**	**55.9**	**73.4**	**72.9**	**81.7**	**2.7**	**23.6**	**47.3**	**28,770**
Heavy covered (Annealed at 1110° F. for 30 minutes)	10	55.3	61.5	56.8	74.7	74.2	82.3	3.2	24.6	51.0	28,400
	11	55.5	61.6	57.0	74.8	74.3	82.3	3.1	26.0	52.5	28,850
	12	56.0	59.8	56.0	74.2	75.5	80.5	2.5	24.1	43.7	28,800
	Av.	**55.6**	**60.9**	**56.6**	**74.5**	**74.7**	**81.7**	**2.9**	**24.9**	**49.1**	**28,680**
Heavy covered (Annealed at 1650° F. for 15 minutes)	13	51.8	55.3	50.5	72.3	71.6	76.4	3.3	32.7	55.0	28,400
	14	54.0	55.2	50.0	72.2	74.8	76.6	3.1	31.2	53.7	27,950
	15	52.5	55.3	49.7	72.1	73.0	76.9	3.6	30.0	46.5	28,350
	Av.	**52.8**	**55.3**	**50.1**	**72.2**	**73.1**	**76.6**	**3.3**	**31.3**	**51.7**	**28,230**
Ship-quality plate	16	30.9	32.6	29.5	58.0	53.8	56.5	1.6	40.0	61.3	29,150
	17	30.4	32.4	28.1	57.1	53.6	56.8	1.5	38.8	62.1	29,100
	Av.	**30.7**	**32.5**	**28.8**	**57.6**	**53.7**	**56.7**	**1.6**	**39.4**	**61.7**	**29,125**

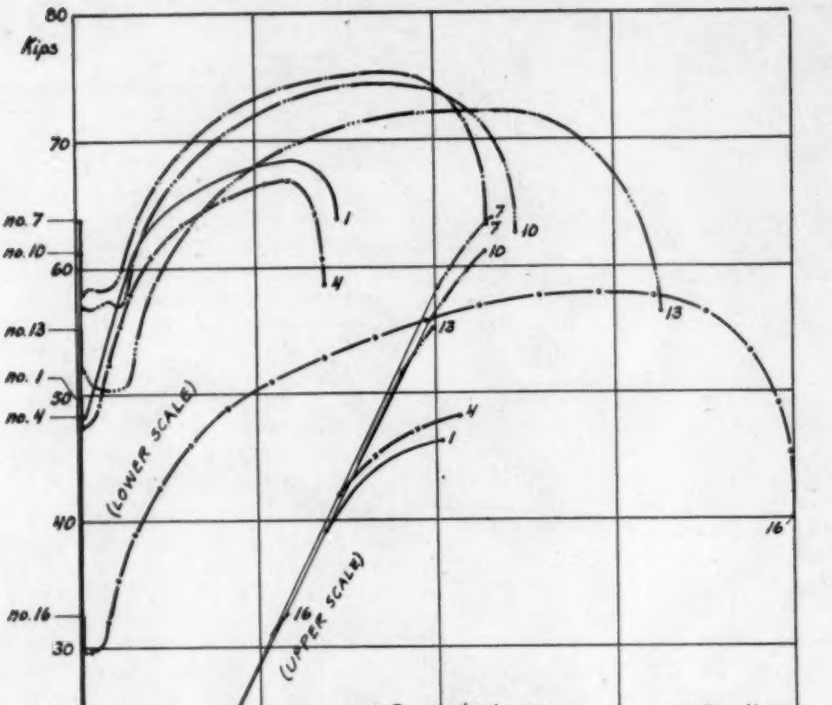


Fig. 2. Stress-Strain Diagrams of Various All-Weld-Metal Specimens and Ship-Quality Plate.

is a trifle lower than that for rolled material, and is the lowest in the case of the weld metal from the bare electrode. At the same elastic elongation as the rolled stock, the weld metal as a consequence of this discrepancy will nominally get a trifle lower stress than the rolled material, but this small discrepancy hardly constitutes any disadvantage.

The ratio of proportional limit (σ_P) to tensile strength (σ_T), and still more the upper yield point (σ_{YU}) to tensile strength (σ_T) (columns 6 and 7 in the table) is higher for weld metal than for rolled steel. Up to the proportional limit for the rolled material, or practically up to its upper yield point, a perfect cooperation of the weld metal and a normal ship-quality steel is secured by all the electrodes which were tested.

For the weld metal, the proportionality between the stress and the elongation ceases earlier than in the case of the rolled material, and therefore the distance between σ_P and σ_{YU} is greater. The reason for this is the local yielding occurring near pores and slag inclusions, caused by an uneven stress distribution in the material. The distance between the limit of proportionality and the yield point, therefore, gives a measure of the inhomogeneity of the material.

In the case of the weld metal from bare and coated electrodes, a relatively great elongation occurs before the upper yield point is reached (see Fig. 2, bars No. 1 and 4). Might it be possible that this "softer" passing to yielding is favorable and causes a more gradual evening of stress differences in the welded joint?

These tests reveal the very interesting fact that the weld metal from all the electrodes which were tested has a pronounced upper and lower yield point. It is necessary to add, however, that the bare electrode used was of excellent quality, not only as regards weldability, but also as regards the strength properties of the weld metal, and it cannot be predicted whether weld metal from any other bare electrode will behave in similar fashion.

For the weld metal from the tested bare and coated electrodes, the yield elongation (δ_1) is *less* pronounced than that of the shipbuilding-quality steel, while for weld metal from the heavy-covered electrode it is *more* pronounced. It is quite apparent that some amount of yield elongation is a valuable asset for a weld metal. In a weld, stress differences and concentrations come up during the making on account of the shrinkages as well as due to external loading on account of the geometrical shape of the joint. Also, pores and weld defects represent local discontinuities around which stress concentrations develop. In every weld, plastic yielding may therefore occur; but, if we assume an even one-dimensional stress condition, this will not lead to any increase of the stresses in the material beyond σ_{YU} if the value of δ_1 is not exceeded. According to such reasoning, δ_1 ought to correspond to or exceed the possible plastic yielding, and it is natural to ask how great this may be expected to be.

So many circumstances have a bearing on this subject that a general answer cannot be given. The shrinkages take place during a wide range of temperatures, the exact size of the stress concentrations caused by the external loading is difficult to determine, and the stress condition is a complicated one and generally multi-dimensional. The problem of yielding and of yield requirements under such conditions is a rather complex one. The following reasoning, however, may be useful in determining the extent of plastic deformation that may occur in a long joint welded continuously.

Method of Calculating Stresses Developed by Cooling

During the process of shrinkage, such a joint in a big plate may be considered rigidly clamped in the longitudinal direction, since the cold plate areas on both sides of the weld will resist the contraction due to shrinkage. Fig. 3 is a simplified diagram of the strength properties of steel at high temperatures. During the cooling period from the molten state and down to about 930°F., no stresses will develop as the value of the modulus of elasticity E is zero at these high temperatures. From then on stresses may arise in rigidly fixed material.

Let us consider at first the cooling period from 930° to 480°F. As the mean coefficient of expansion for ordinary rolled mild steel in this temperature range is $\beta = 8.0 \times 10^{-6}$, the weld will shrink $\frac{8.0 \times 450}{1{,}000{,}000} = 0.360\%$. If we assume a mean value of modulus of elasticity $E = \frac{29{,}000}{2} = 14{,}500$ kips, this shrinkage will cause a stress in the

material of the magnitude $\sigma = \epsilon \times E = 0.0036 \times 14{,}500 = 52.2$ kips. The yield point of weld metal in a one-dimensional stress condition is therefore reached, and further contraction will cause plastic deformation. When cooling from 480°F. to, say, 30°F., the weld metal (with a linear coefficient of expansion $\beta = 6.9 \times 10^{-6}$ between these temperatures) will shrink $\frac{6.9 \times 450}{1{,}000{,}000} = 0.31\%$.

When cooling is finished, the stress condition in the welding zone will therefore correspond to yield requirements—as tests conducted by Bollenrath have proved—and besides it will have suffered a plastic deformation the maximum of which may be some 0.3%. Generally, however, this deformation will be lower, both because of the higher yield point of the material at multi-dimensional stress condition and because the absolutely rigid fixed condition presumed will not usually be realized in practical welding.

If the plate is now loaded in the longitudinal direction of the weld to a stress which corresponds to the yield point of the plate material, the weld will elongate plastically still further. With the yield point of the plate assumed to be 40 kips, the elongation would be $\epsilon = \frac{\sigma}{E} = \frac{40}{29{,}000} = 0.14\%$. The total plastic deformation due to shrinkage and external loading should therefore in this case possibly amount to some $0.3 + 0.14 = 0.44\%$.

Elongation of Welds Consisting of Multiple Layers

The elongation which may occur in the weld perpendicular to the joint when during the process of welding this has a smaller section than the plate (using multiple layers), depends very much on the weld conditions and may, under adverse conditions, amount to several (say, 2 to 4) per cent. As every new layer gives an annealing of the preceding ones, the behavior of the weld metal becomes primarily a problem of fabrication, which may be considered solved when the welded joint is finished without shrinkage cracks.

The plastic elongation required to equalize local stress concentrations will usually amount to only a few tenths of one per cent.

As shown in the table, the values of the yield elongation (δ_1) for the electrodes tested vary from 0.7% for bare electrodes to 3.3% for weld metal annealed at 1650°F. from heavy-covered electrodes.

The table, as well as Fig. 2, also records the elongation after fracture (δ) of the test bars. The maximum value obtained with bare electrodes (14.8%) and with coated electrodes (14%) is higher than usually associated with these types. In the cases of bars No. 2 and 5, the fracture, as mentioned before, was partly coarse-crystalline, probably caused by overheating during welding. The elongation after fracture (δ) and the contraction (ψ) for these bars were considerably reduced, but it is interesting to note that all the other strength values were unchanged. The bars welded with heavy-covered electrodes showed excellent elongations (23.6% average), as is usual for this type, and these values were even bettered considerably when the bars were annealed at 1650°F.

The problem of cooperation of the weld metal and the parent metal involves, of course, also the transition zones existing between these metals, as well as the strength of the weld under shock and fatigue stresses and resistance against corrosion—problems which will not, however, be dealt with here.

The stresses induced in a joint during welding, as well as those due to external loading, must be reckoned as possibly exceeding the yield point of the material. The cooperation of the weld metal and the parent metal at stresses near the yield point is therefore of great practical consequence. The yield point of the weld metal, in consideration of the stresses perpendicular to the joint, should be high, but on the other hand, due to the forces longitudinal to the joint and the multi-dimensional stress condition, should not be essential higher than the yield point of the parent metal.

Need for Similar Tensile Properties in Both Weld and Parent Metal

The weld metal, therefore, preferably should have tensile properties corresponding closely to those of the parent metal to which it is applied. As the ratio of yield point to tensile strength (σ_Y/σ_T) is higher for weld metal than for rolled steel, the above requirements appear well fulfilled when *the weld metal possesses the same tensile strength as the rolled steel*, and even lower tensile strength may be justified.

The excellent strength properties now obtainable with heavy-covered electrodes, combined with the high ratios σ_P/σ_T and σ_Y/σ_T, eminently fit this material to cooperate with the new low-alloy, high-tensile, corrosion-resistant steels of good weldability which have been developed in the last few years.

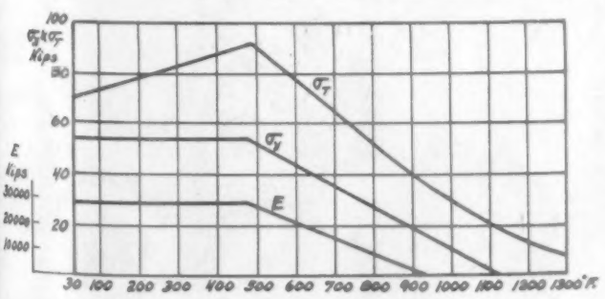


Fig. 3. Simplified Diagram of Strength of Steel at Various Temperatures.

Safety Congress to Have Papers on Welding

Two papers on welding will be presented at the session on Tuesday morning, Oct. 15th, during the 24th Annual Safety Congresss, to be held in Louisville, Ky., Oct. 14th to 18th. J. R. Dawson, research metallurgist, Union Carbide & Carbon Research Laboratories, will speak on "The Welding of Chromium Steels in Chemical-Plant Equipment," which will be followed by a paper on "Welding and Cutting in Tanks and Other Small Unventilated Places," by H. F. Reinhard, chemical engineer, Carbide & Carbon Chemicals Corp. A discussion will follow each paper.

Experiences With A. C. Welding

By R. D. EAGLESFIELD

With alternating current, an entirely new procedure has been set up for manual and automatic welding. The crystal growth produced in the a.c. crater is radically different from anything we have ever studied in the past. Any sudden chilling action is beneficially retarded through the current reversals represented by the frequency of the a.c. circuit. This agitation very definitely permits a fine-grained structure to grow, as is shown by examining the fractures produced by nick-break tests.

Mechanically, the a.c. puddle behaves in a superior fashion, and this shows up especially well in fillet welds, as the metal does not overlap and there is but little tendency to entrap slag. The delayed solidification enables the gas to work out, and the resultant weld metal is easy to manipulate.

It so happens that in the last fifteen years I originated and put on the market high-frequency-motor-driven woodworking machinery, using frequencies from 120 up to 540 cycles per second, resulting in motor speeds of 33,000 r.p.m. We have put out hundreds of frequency changers for this purpose. In the past few months I have been checking the results obtained on these frequency changers by different frequencies, with a view of studying the puddling action of the alternating-current arc. The results of these tests, and of tests made with electronic tubes with

pulsating direct current, will be published later.

Magnetic blow is ever present with direct current. Experiments are continually being made to reduce this phenomenon, but of course worries along this line are over with when alternating current is used.

Moreover, the passing of weld metal across the arc during the fusion process results in surges that tax any method of stabilization with a d.c. generator.

Valiant efforts have been made by good engineers to overcome this instability, but in my opinion, the cure is worse than the disease. However, this is another bogy that we don't have to worry about with alternating current, because the short-circuiting periods are overcome by the design of the a.c. field, whether it be rotating or stationary.

The d.c. arc, of course, has a normal characteristic of going to a cold spot in preference to a hot one, because of the fact that the cold spot offers less resistance. Welders refer to this trouble by saying the arc is "pulling off."

Those who claim that the stability gained in d.c. welding through the use of reversed polarity is lost with a.c. welding overlook the fact that this reversed polarity is employed to prevent something that does not exist with a.c. welding. As a matter of fact, the increase in the stability of the a.c. arc permits the use of very high currents.

Minor changes, of course, such as a heavier flux coating on the rod, are necessary. These coatings are designed to form a mechanical shield around the arc, giving an arc that is uniform in length and easy to maintain. Incidentally, this mechanical shield results in a very directional arc. One of the first things noticed when welding with alternating current is the "obedience" of the arc stream.

This very "obedience" of the arc causes some odd complications. The other day we were called out on a hundred-mile trip to find out why a new a.c. machine had quit producing its normal output. If we hadn't had the same experience with a 1000-kw. alternator some years ago that persisted in burning its cables out as fast as they were put in, we never would have thought of the simple remedy that cured the trouble in this case.

The welder leads, which were 400 ft. long, were running over a steel floor and they were widely separated. Naturally, an enormous amount of the current was being used up in induction. If, of course, the leads had been small enough they would have simply burned up, as they did in the case of the alternator. In the latter case, the leads were in individual conduits, and when the current was turned on the induction simply melted the insulation off of the cables and naturally there was a dead short.

To correct this trouble with the welder, we simply took some binder twine that was available and tied the cables together their full length and got them off the steel floor. The voltage drop then was not particularly noticeable, because the cables were of proper size and the machine had ample capacity to take care of the loss due to the reactance.

One manufacturer has overcome this trouble by making his welding cables in pairs.

The other day we were called down to a large mine where they were hard-facing the inside of heavy chains. They had three types of d.c. welders—the old brush shifter, the regular d.c. machine with an external stabilizer, and one of the latest d.c. machines with the stabilizer reactance designed in the field. All three machines were tried, and in every case the metal would "blob" all around the links, and the links offered a magnetic path that made it almost impossible to weld with the direct current.

They tried all methods of getting around this magnetic "blob," such as making a complete enclosure for the chain lengths treated. They were just about ready to design a magnetic field to oppose the field set up in the link by the arc blow, when it occurred to them to use their a.c. welder on this work. They hadn't thought about using the a.c. machine, because they had been told that it was suitable for heavy work only, and this job of course called for low current, as the hard-surfacing material was expensive and they wanted to put it where it belonged and in as thin a coating as possible.

They set the machine to the proper current value, and their troubles were all gone. In fact, the arc that was made with the a.c. welder more nearly resembled a flame of a properly directed gas torch, and the welding operators were delighted with the outcome.

These links were coated to a distance of about ½ in. back beyond the wearing areas, the coating covering about 2 in. of the 12-in. circumference of the link. On checking up on the amount of rod used, it was found that not only a better wearing area was being obtained than formerly, but a great deal of electrode was being saved, due to the characteristics of the a.c. arc with the absence of arc blow. Incidentally the welders made better time on the chains, because they soon found out that they could turn their heat up and deposit their metal much faster, due to the fact that they were having a great deal less spatter loss, and the spatter of course had to be watched carefully on this high-price abrasive-resisting electrode.

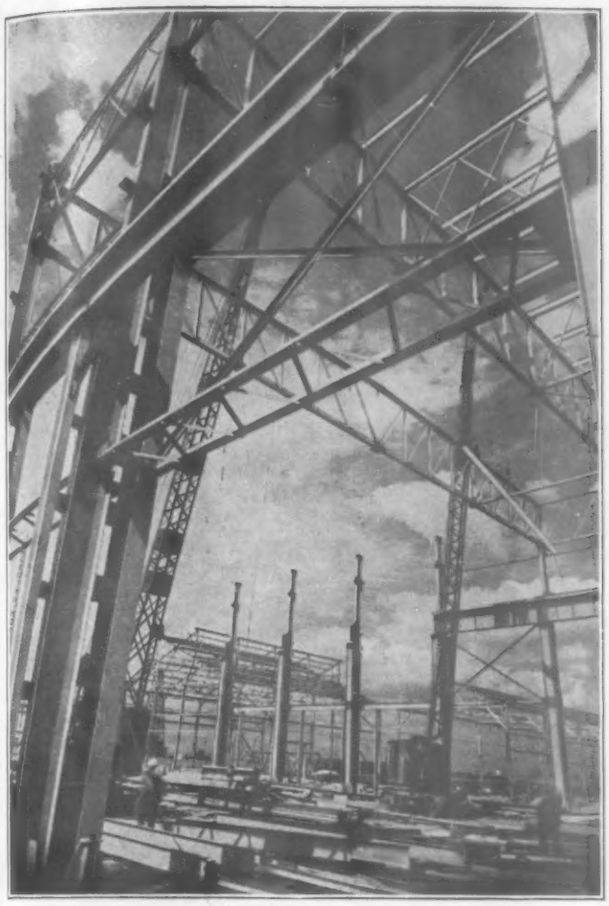
A good type of easily detachable connector is available so that ground plates or clamps can be quickly attached to one of the conductors and the electrode holder to the other cable. A good many users have an extra flexible cable about 10 ft. long with one of these quick-detachable connectors on one end and an electrode holder on the other so that when the electrode holder gets hot from use they simply detach the hot one and put on a new lead and holder.

This certainly makes it easy for the welder, and details like this can't be given too much consideration. Welders spend their lives welding with electrode holders that in many cases are too hot for comfort, but they don't stop to figure any easier way out of it and simply continue welding with the uncomfortable holder.

It has been believed in this country that a.c. welding is suitable only for heavy work, but this has been disproved in Europe, where a.c. is used on gauges that are so thin that we would not contemplate welding them in this country. In the past few years quite a good deal of work has been done along this line in this country, but we are still behind the times in this respect. We seem to have spent our time entirely along the line of bettering d.c. welding, rather than concentrating on the result,—which is the weld metal itself. Also, the Europeans are doing things with a.c welding on vertical and overhead work that we don't even yet contemplate doing.

This was brought to my mind very forcibly the other day in one of the Southern cities, where I was called by a plant to show them some of the characteristics of a.c. welding. Of course, I was prepared to go down there and show them how well they could handle their vertical work with a.c. welding, and how the highly directional effect of the a.c. arc made it especially advantageous for cutting through cast iron, since they had much of this kind of work to do. Much to my surprise, I found they had an old German welder who had been used to a.c. welding, and he was literally writing his name with the a.c. arc. One of the stunts that he did was to take a ⅜-in. electrode and weld very satisfactorily on ⅛-in. plate, using the same current that would normally be used with a ⅛-in. electrode. Of course, the melting rate was very low, but the current used would never have operated a d.c. arc. The ionization effect would have been too small and a much larger arc stream would have had to been carried, which of course would have prevented the welding of light-gauge metal with that size of electrode.

This is perhaps one of the best demonstrations of the value of the ionizing current in maintaining the arc. Steps have been made in this country to use a carrier current for maintaining a very low current across the arc for certain types of thin-gauge welding.



Erecting the Welded-Steel Framework for the 550-Ft. Main Erection Aisle.

Having full confidence in welded construction, the Electro-Motive Corporation specified that the thirteen units of their new plant be constructed entirely of

Arc-Welded Structural Steel . .

THIRTEEN all-welded buildings, involving about 2,000 tons of structural steel, are being erected at the new factory site of the Electro-Motive Corp. at McCook, Ill., a few miles southwest of Chicago. Approximately 50,000 ft. of welds will be laid, requiring 7½ tons of electrodes. The general contractors for the plant are the Austin Co. of Cleveland, Ohio. In awarding the contract, welding construction was specified by the Electro-Motive Corp.

Welding Is Used in the Product, So Why Not in the Building?

"We wanted welded structures because we know just exactly what to expect from that type of construction," says H. L. Hamilton, president of the Electro-Motive Corp. "The products of this plant, consisting largely of Diesel-electric locomotives, will involve a considerable amount of welding in their construction. The frames of the Diesel engines, which will be shipped to our plant for assembly onto the locomotive frames, are entirely welded and this type of construction has been highly successful. Naturally, if welding stands up under such service as that encountered in Diesel-engine operation, it is also an ideal means for fabricating steel structures. Moreover, welded buildings are more in keeping than riveted construction, with the type of product that we will make. We are enthusiastically sold on the merits of welded construction, based on actual data."

Methods of mass production will be used in the assembly of these giant locomotives. These locomotives will take form as they move crosswise in a 104-ft. aisle which extends for a distance of over 500 ft. There will be 24 construction bays, into which frames, parts and engines will be moved with the aid of a 200-ton, 40-ton and 30-ton traveling crane. By using overhead cranes for the moving of the work instead of a carrier belt as in automobile production, the interruption of production at any point in the line will not affect the work at other stations. The buildings forming the factory unit are as follows:

BUILDING	SIZE	NO. OF STORIES
Office	40x140 ft.	3 Stories and Basement
Employment Office	22x 47 ft.	1 Story
Erection Shop	104x552 ft.	1 Story
Machine Shop	67x552 ft.	1 Story
Parts Department	60x120 ft.	1 Story
Paint Shop	50x140 ft.	1 Story
Sand Blast	30x140 ft.	1 Story
Blacksmith Shop	72x 80 ft.	1 Story
Garage	30x .72 ft.	1 Story
Annealing Oven	24x180 ft.	1 Story
Warehouse	48x140 ft.	1 Story
Power House	48x 60 ft.	1 Story
Gas House	24x 30 ft.	1 Story

Progress is sufficiently along in the construction of this plant that the

Machine Shop (Nearest Bay) and Erection Shop (Farther Bay) Under Construction.
(The steel is being progressively erected towards the north, or left of photograph.)

Welded Columns as Delivered to the Job.
(The locomotive crane is about to remove a load of stiffener trusses from the gondola.)

Electro-Motive Corp. expects to start production of locomotives in November. The plant as laid out will have a capacity of about 22 million dollars worth of locomotives per year.

In addition to the welded steel framework of the various structures, all steam lines and air lines larger than 2 in. will also be welded and the gas line connecting the plant to the natural gas main is also entirely welded. Shielded-arc electrodes are being used throughout, except in the case of the piping, which will be oxyacetylene welded.

Welded Crane of 200-Ton Capacity Will Operate in Erection Aisle

The main erecting aisle of the plant will carry the heaviest traveling crane ever operated on a welded structure, and the big 200-ton crane itself is said to be the largest all-welded crane ever built and has a dead weight of approximately 205 tons.

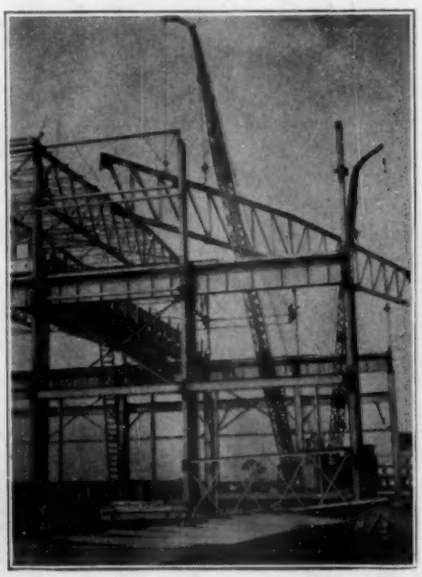
In addition to the other two cranes in the erection shop, rated at 40 and 30 tons capacity, the machine shop will also have two 20-ton traveling cranes, and a 15-ton gantry crane will run at right angles to the direction of the erecting aisle and at its north end. All these cranes will be of welded construction.

The girder trusses, stiffener trusses, beams and columns are fabricated individually in the Austin Co. plant at Cleveland and shipped by rail to the site. The choice of welding in the construction of this plant has greatly simplified erection problems, according to G. M. Hunting, superintendent of erection at the site.

Welding the Gas Line Leading to the New Plant of the Electro-Motive Corp.
(The steam plant is in the center background.)

Welded Construction Simplifies Erection Problems

"Welded structures, such as these buildings, are far simpler to erect and the parts are much easier to handle than in the case of riveted structures," says Mr. Hunting. "For example, an



Erecting an All-Welded 104-Ft.-Span Roof Truss.

85-foot all-welded truss needs only a choker at its peak to handle it. By merely putting a sling on the peak of the truss, such trusses have been erected in only ten minutes."

The erection shop has two rows of columns running north and south and spaced 104 ft. between rows, with 24 ft. between adjacent columns in the same row. Adjoining the erection shop on the west is the machine shop, which extends the same length as the erection shop—namely, 552 ft.—with a span of 67 ft. between rows of columns.

Columns Designed for Total Load of 750,000 Lb. Each

The columns in the line between the erection shop and machine shop are designed for a total load of 750,000 lb. and might be considered as typical of column construction for these two buildings. These columns each consist of a main shaft with a stub column on the east and another one on the west. The main shaft consists of a 24-in. 74-lb. I-beam, together with minor details and a base plate. The stub column on the east side (in the erection shop) is a 21-in. 68-lb. I-beam, with other details, and the stub column on the west side (in the machine shop) is a 12-in. 32-lb. I-beam. The base plate supporting the main

Base of Column on Line Between Assembly Shop and Machine Shop.

shaft and the two stub columns is a 1-in. plate, 38 in. wide and 6 ft. 6 in. long.

The columns along the east side of the erection shop and the west side of the machine shop are of somewhat the same general design as the interior columns just described but have only one stub column besides the main shaft.

The roof trusses of 104-ft. span for the erection shop employ spit I-beams for diagonals as well as for top and bottom chords. The top and bottom chords consist of one-half of 24-in. I-beams of varying weight split through the center of the web by a mechanical cutter.

Trusses of 24-ft. span are used to stiffen the main trusses. These stiffener trusses employ T-shaped sections as chords, made by splitting 12-in. 28-lb. I-beams, and angles are employed as diagonals.

Welded Plate Girders Support Crane Runways

Plate girders are used to support the crane runways. In the erection shop these girders are 23 ft. 11 in. long and are made up of a web plate ¾ in. thick

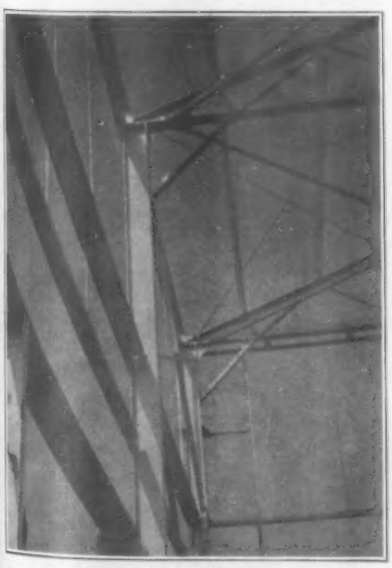
Welded Crane-Supporting Girders as Delivered to the Site.

and 54 in. high with a top flange plate 1⅛ in. thick and 30 in. wide, and a bottom flange plate ⅞ in. thick and 16 in. wide. Stiffener plates 6 in. wide and ½ in. thick are welded at intervals to the web and flange plates by intermittent welds. This might be taken as typical of the construction of all girders for supporting crane runways. The absence of one column makes it necessary to supply one double-length girder (48 ft. long) for the gantry crane, which will of necessity be considerably bulkier than the girder just described.

Steel Is Erected, Then Plumbed, and Welded

There are three sequences in the erection of steel work for all buildings: (1) Complete assembly, (2) fit-up and plumbing and (3) welding.

All members are delivered to the site drilled with erection bolts to facilitate quick set-up. In the case of the erection shop and machine shop, the steel is erected beginning at the south end and progressing toward the north. Those charged with fitting up and plumbing the steel follow about two panels behind the steel erectors. After the columns are plumbed, all erection bolts are tightened, ready for welding. The erection bolts are not removed, but are "spotted" by the welder when he finishes welding the joint. This insures against the bolts working loose. It is said that this method greatly facilitates the speedy and accurate progress of the job. Each crew has its specific duties to perform, and the welders are saved the trouble of handling any of the details and they can devote their entire time to welding.



Showing Connections Between Columns and Roof Trusses in the Blacksmith Shop Building.

The frames of all locomotives manufactured at this plant will be welded and followed with an annealing treatment. Annealing ovens are being constructed of such dimensions as to accommodate the entire frame of the largest locomotive at one heat.

The plant unit being constructed has the office building located at its south end and the boiler plant at its north end, with the erection shop and machine shop extending between. Jutting off the machine shop are the Parts Department Building, Paint Shop Building, Sand Blast Building, Blacksmith Shop and Garage, Annealing Oven Building, and Warehouse Building. Land is available for doubling the capacity of the plant by an extension at the north end of the present unit. Should the second unit be built, the total capacity again can be doubled by another double unit like the first in space provided for that purpose to the west of the then existing plant, except that the plans for the new unit would be reversed, the machine shop being on the east and the erection shop on the west.

Base of Column of Blacksmith Shop Building.

Cast-Iron Crusher Repaired By Arc Welding

At a total cost of only about $30, an expenditure of about $600 for a new casting was avoided through the use of welding by the Prow-Leffler Co., of El Monte, Calif. The job consisted of repairing a break at the corner of the base of a Gates Type 3D Allis-Chalmers rock crusher, as shown in the accompanying illustration. The break in the casting occurred at a vital point in the base, being at the corner where bolts were necessary to secure the crusher to its foundation.

As the broken piece was lost, it was replaced by building in a section, which was done by welding in two pieces of steel plates (see arrow in photograph). The procedure was to chip the edge of the casting smooth and place a piece of ordinary strap iron against the edge, through which were drilled holes for studding into the casting. Holes were likewise drilled in the edge of the casting, into which ⅝-in. and ¾-in. cap screws were inserted about 3 in. and left protruding as studs.

When the stud bolts were all inserted, welding followed by laying the first bead in around the studs and the piece of strap iron. After completion of this operation, the edges of the plates forming the missing corner were welded to the strap iron. As the casting was 2½ in. thick, it was not deemed necessary to use plates of sufficient thickness to equal the thickness of the casting, so two pieces of ½-in. plate were used and an outside edge filler welded in to fill out and finish the side edges.

By employing electric welding on this job, no preheating was necessary, ordinary caution being taken by frequently shifting from one area to another during the welding in order to prevent an excess of heat in any one section of the job at a time. Electrodes of 3/16-in. size were used. The job was completed in about 11 hours, the welding being done by and under the supervision of L. R. Luecke, welding foreman of the Prow-Leffler Co., which concern specializes in the repairing of rock-crushers and heavy highway maintenance equipment.

Arrow Shows Steel Plate Welded to Crusher Base.

Get "*H.O.T.*" on Welding

■ By H. O T. RIDLON

[This section is dedicated to Better Welding and Better Welding Shops. Suggestions and criticisms are invited.]

The Open Season Starts for Welding Shows

I have studied welders and welding shops for nigh onto twenty years, man and superman, and during that time have seen many pathetic souls, foreign and domestic, here and abroad. Among them have been those most generally accepted as the greatest. After colossal cerebration, I am forced to announce that the monarch of them all is—not yet even a gleam in his father's eye.

On the contrary, this great, near-great, or would-be-great welder is the born victim of hapless, blundering Humanity, masquerading in tatters of splendor, hoping with all his little heart that he is fooling you into a belief in his respectability and potentialities for success. He skitters from one jam to another, the perpetual optimist, radiant with trust and confidence, always assuring you—and himself—that this time at last it's going to come out all right; it seldom does, and most of the things he does are only very short of failure; thwarted and confused, he nevertheless clings to his faith; bravely beaming, he picks up his battered body and bruised soul, and rushes valiantly into the next disaster.

I am often reminded of a slightly constipated pup.

What brought all this on, you may rightfully ask of the Old Maestro. It happened this way: Today I was sitting in the office of a most swellogant gent and one that really has some idea what it is all about. We talked about many things, among them the lack of good salesmen, then the oncoming series of welding shows and conferences, and then we started adding to our list of "Things I'm Too Used To."

We'll skip the salesman problem, because I'm one of them, and charity should start at home.

But I will talk about the other two, and may intermingle them somewhat to give you the ideas I have about them.

Beginning September 11th, starts the open season for welding shows and conferences. That is the starting date of the National Tool Show in Cleveland. One worth attending, and it runs for ten days. The following week is the Iron and Steel Show in Pittsburgh. Then the first week in October is the American Welding Society Fall Meeting and the National Metal Congress in Chicago. That's plenty for any six men and a boy for a while. But the middle of November finds us again in Cleveland at the International Acetylene Association convention. Then in rapid succession are the Purdue, Ames, Ohio, and so on, welding meetings. All these are worth attending to any one interested in welding, whether he does the welding or employs it done.

There are two ways of attending these great shows:

One, by walking in, looking about for fifteen minutes, sort of grunting and saying to yourself or your pal, "Same old torches, with some minor changes that don't make any difference, and the same old arc machines with a new cover," and then out to find some sucker peddler who will sit down over a bottle with you and perhaps take you in a quarter stud game.

Then there is the way of going in to get everything out of it you can. If you do that, there won't be time enough to get it all in. In each one of those booths are very competent sales engineers and welding engineers from whom you can get much help and many very excellent ideas that mean profit to you. The companies that send these men there don't do it because they want to spend money to watch the equipment they have on display and to keep it in order. They could send an office boy, who would probably do that job better. But these companies send their best talent—why?—because they want to help you to profit in this industry, for they know that when you profit, they profit, and therefore they are willing to spend many hundreds of dollars on these shows each year. Each man in those booths is an expert in his line—and some of them are overly modest—but he is there to answer your questions, no matter how silly they may seem to you, to work out your problems there, or in his experimental shop, or in your own shop with you. He likes to talk about the things he knows. You will find him a very fine fellow (competitors included), who is a business man, there on business, ready, anxious and willing to talk with you. And here's a secret you may never have guessed before, but 99 cases out of a hundred he would much rather talk with you than drink with you. So go to all these conferences you can and corner these guys that stand up in the booths and look wise and you will find that the darn thing is all too short and that you will come away with many ideas from which you can profit.

But here let me give you a "Hot Spark": No idea is worth a damn, until it has been put into action.

• • •

Many welding-shop owners insist on buying acetylene generators that fall way short of giving them the maximum capacities they will need. I have long maintained that generators should be bought with the large jobs in view. A large generator will do the small jobs and have time because it is not always empty. Then when you hop on a real he-man job, it will work right along with you. The big tips use the most acetylene—and it is then that the generator is most profitable. When you buy anything in the way of equipment consider well before you do it. And know what you are doing. There is a world of knowledge available to you for the asking. Don't be one of those many whose shops are tatters of splendor, with a generator that just can't put out enough of that stuff for you, or a good torch, and one or both regulators on the bum, leaky hose, and so on. Get some welding engineer to lay out your shop for you, and if you can't get the cash to put all his good ideas into effect, build to that end.

• • •

Continually I am seeing welders throwing away burned and partly burned pieces of asbestos paper. Keep a pail of water handy and throw that stuff into it. It is swell for shimming up something, or backing up a job, or stuffing into a crack of your preheating furnace to keep a dangerous draft away from some tricky job that you have sweated over for hours.

• • •

I'm still on that business "Get 'H.O.T.' for President" stuff, although it is a bit early to fire my guns, and my plan is to wait until I see the whites of my enemies' eyes (but I believe they will be hard to see, for me thinks they will be rather blood-shot by that time). However, my platform is, More soap and less soap-boxes, in this country.

• • •

Thanks, Mr. Dan Staley, sales manager of the Stoody Co., and editor of *Fusion Facts*, for all the nice things you said about my new column, "Get 'H.O.T.' on Hard-Surfacing," in your magazine. Honestly, I don't feel that I have had any more experience than anyone else. It is perhaps only that I learned very early in life to use my yesterdays as stepping-stones to my advantage, instead of mill-stones about my neck.

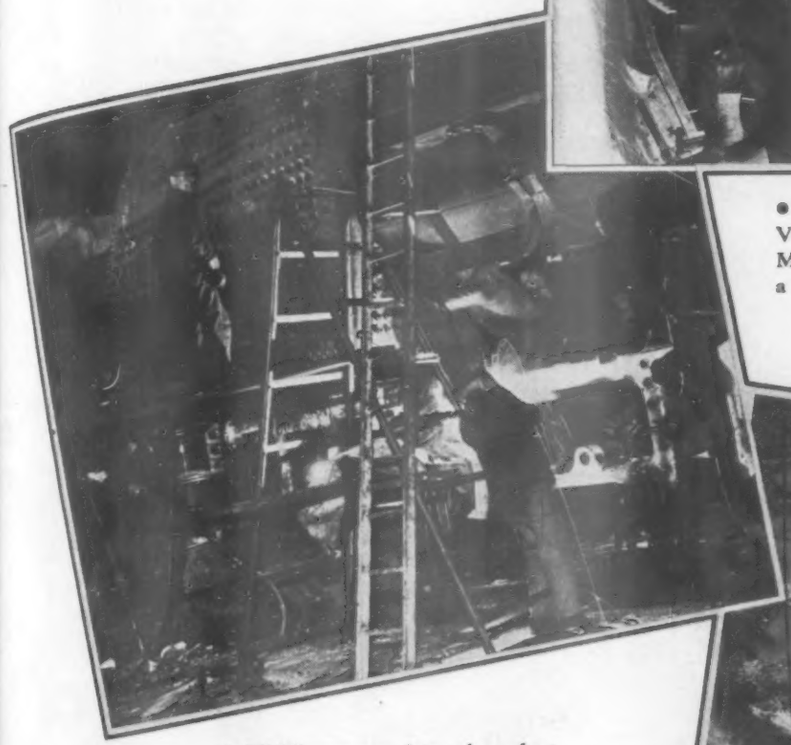
• • •

The thought for the month: Live today, as you would die tomorrow.

WELDING NEWS
▪ IN PICTURES ▪

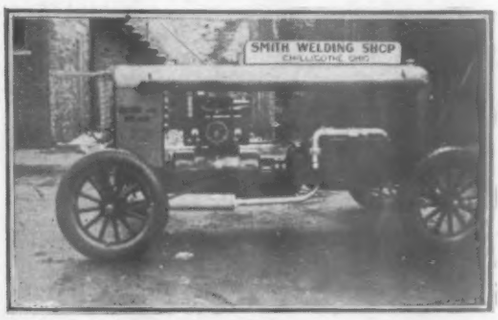
• A picturesque setting for a welding shop. The location is North Bend, Wash. Saw repairing by welding, is one of the trades in this region.

• "Balloon" welder fashioning all-steel Ford V-8 bodies at the Rouge Plant of the Ford Motor Co., Dearborn, Mich. This welder has a capacity of 1100 "balloon" sections a day.

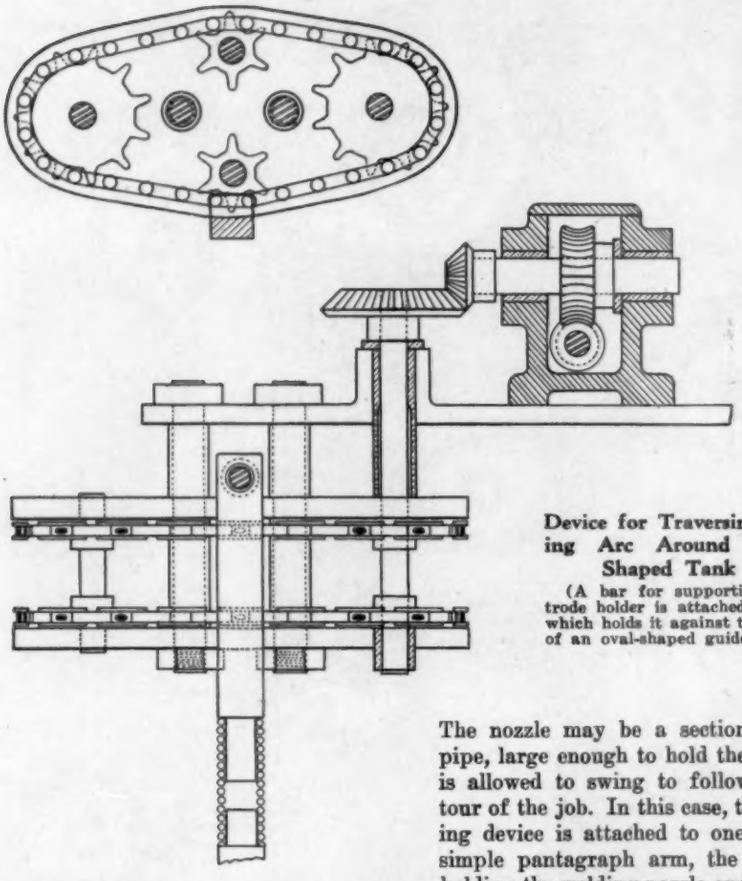


• Welding comes into play when this B. & O. locomotive receives an overhauling.

• Using the electric arc in the construction of a bridge over the Rocky River Valley, on Lorain Road, Cleveland, Ohio. (Photo courtesy of The Lincoln Electric Co.)



• Built to specifications to meet special requirements, this portable welding outfit meets the needs of the Smith Welding Shop, Chillicothe, Ohio, when on field work.



Device for Traversing a Welding Arc Around an Oval-Shaped Tank End.

(A bar for supporting the electrode holder is attached to a chain, which holds it against the periphery of an oval-shaped guide plate.)

Motor-Driven Traversing Device for Arc Welding

By A. M. MAC FARLAND

For traversing a welding arc, either carbon or metallic, around a tank end of oval or irregular shape, the device shown in the diagram was constructed, and has been in successful operation.

A bar for supporting the electrode holder travels around the profile plates, which are shaped to match the outline of the tank head. In the illustration, these plates are oval-shaped. The bar is held against the periphery of the guide plates by a bicycle chain, to which the bar is attached and by which it is carried around the plates. One of the idlers is held outwardly by a strong spring, keeping the chain taut and holding the bar tight against the plates.

The bar has a flexible neck, with a handle swivel-mounted on it, so the operator may divert the arc to one side or the other to follow exactly the desired path.

If a carbon electrode is used, the carbon holder is attached so that the carbon will be in line with the bar and beneath it. In the case of a metallic electrode, the attachment is the same.

If an automatic head is used, feeding welding wire off a reel, the head must be located well above the traversing device, with a long nozzle of the semi-automatic type bringing down the wire. The nozzle may be a section of small pipe, large enough to hold the wire, and is allowed to swing to follow the contour of the job. In this case, the traversing device is attached to one end of a simple pantagraph arm, the other one holding the welding nozzle and following the work.

This device may be used on oval or rectangular tanks, or, in fact, on any shape in which the angles are not too sharp to follow. It can be built in the ordinary tool room for about $80, including a ¼-hp. motor and a 50-to-1 reduction gear.

Spot and Seam Welding Brasses and Bronzes

By R. L. BRIGGS
Thomson-Gibb Electric Welding Co.

For some time the leading brass companies have been busily engaged on the problem of developing brass and bronze alloys particularly suited for fabrication by resistance-welding methods. Our engineers have been contributing their knowledge of resistance-welding methods and requirements to this important project and have turned up some very interesting facts about these metals that may help in the efficient handling of them.

Are you aware, for example, that you can spot and seam weld many types of brasses and bronzes on your present standard welding equipment? Some alloys of copper require extra-large-capacity welders, it is true, but that is by no means the case with all brass and bronze alloys.

Like any other metal, brasses and bronzes must conform to the three basic requirements of a good welding material:

First, the welding power requirements must be reasonable.

Second, the welds must be satisfactory from a metallurgical and physical point of view.

Third, the life of the welding points or rolls must not be materially shortened.

Let's see how brass and bronze alloys measure up to these requirements.

Resistance-welding-current requirements are in direct proportion to the conductivity of the metals to be welded. Non-ferrous alloys requiring large values of electrical capacity are usually hard on welding dies and rolls. As a general rule, good conductors are poor welding metals, and vice versa.

For example, pure electrolytic copper *can* be seam and spot welded, but it requires very excessive welding capacities and special die materials, and the life of the dies is extremely short. Hence, it is considered a very poor welding stock.

Using 0.040-in. stock and ¼-in. rolls or ¼-in. electrodes as a basis for figuring, here are the approximate current requirements for seam or spot welding brass and bronze alloys of various degrees of conductivity:

Per Cent Conductivity	Seam KVA	Spot KVA
90	350	250
80	325	225
70	300	200
60	275	175
50	240	150
40	200	125
30	160	100
20	125	80
10	95	60
5	75	40

There are several important exceptions to this table, particularly for alloys containing nickel. Nickel greatly increases the rate at which conductivity decreases with rising temperatures; hence, nickel alloys will weld at lower temperatures than the table would indicate.

According to our standards for good welding materials, here is how some of the more-common brass and bronze families compare on the matter of weldability. They are graded by the following classification: Excellent (X), very good (VG), good (G), fair (F), and poor (P).

BRASSES		
Alloy	Name	Weldability
100 Cu		P
95 Cu, 5 Zn		P
90 Cu, 10 Zn	Red Brass	P-F
85 Cu, 15 Zn		F
80 Cu, 20 Zn		P-G
70 Cu, 30 Zn		G
66 Cu, 34 Zn	Yellow Brass	G

BRONZES		
Alloy	Name	Weldability
100 Cu		P
95 Cu, 5 Sn		F
90 Cu, 10 Sn	Commercial Bronze	G
85 Cu, 15 Sn		VG

Replacing some of the zinc with other elements in the high-copper families often has a favorable effect on the weldability of the alloy. Manganese, nickel,

silicon and tin are particularly effective. This is true only as a general rule, however, because more of some elements beyond a definite limiting point has a negative reaction. Aluminum, for instance, adds to the weldability of an alloy until 3% has been added; from 3% up, the weldability begins to decrease again.

Before undertaking to weld a brass or bronze of unknown or uncertain qualities, it might be well to check with some manufacturer of resistance-welding equipment.

Welding Shop Puts Out Advertising Folders

A series of eight very attractive 4-page folders has been issued by the Storts Welding Co., Meriden, Conn., to their customers and prospects to demonstrate the dependability and artistry of "Storts-Welds." The inside spread of each folder shows between 20 and 30 jobs of a wide variety welded by the Storts organization. These eight folders show a total of about 200 such jobs.

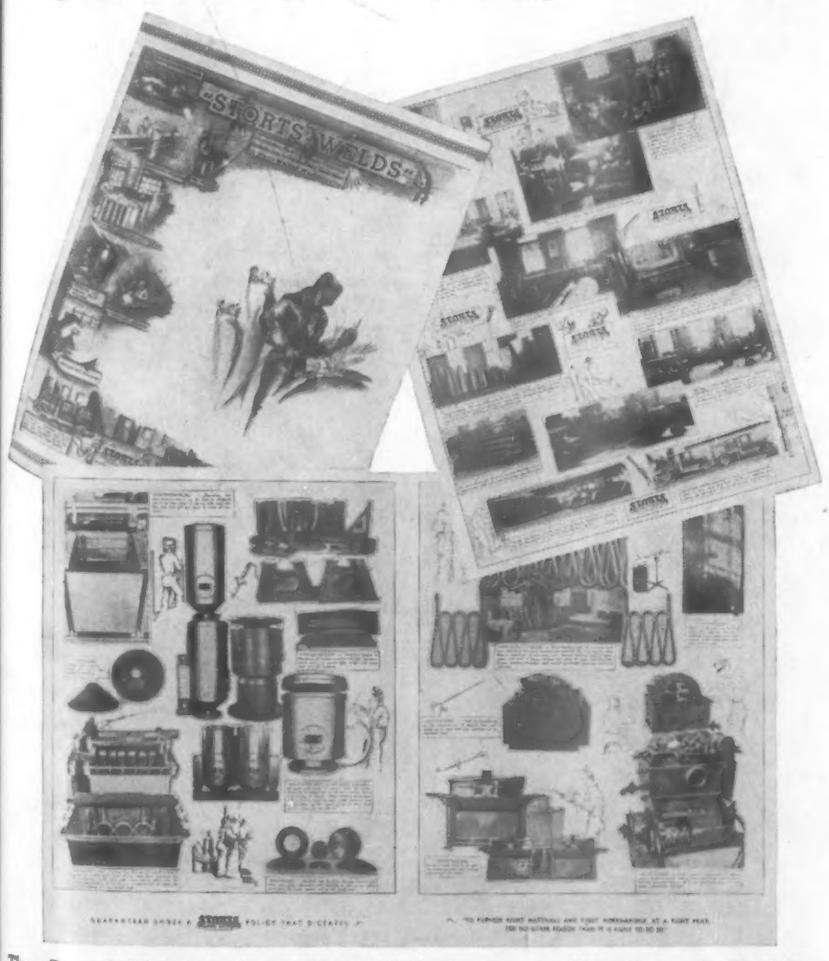
The first page of each folder contains a group of sketches showing various types of welding operations. This page is the same in all the folders, except that the large illustration is changed. Two different groups of illustrations are used as back pages, one showing views of the offices, planning department and library, and the other depicting the various types of welding equipment in the plant, stocks of plates and other materials, and field equipment and delivery trucks.

"The purpose of the folders is to furnish old customers, new customers and prospective customers with monthly reminders that our facilities can be relied upon for producing welding fabrications to their complete satisfaction," states J. D. Tierney, of the company.

"All of the snapshots shown on pages 2, 3 and 4 of each folder were taken with our own camera from time to time as the work passed through our shops, and they represent evidence and proof that our service offers a wide measure of welding versatility.

"The pencil art work with which we have dressed up the folders is the work of a young student, a chap 18 years old who has just graduated from our local trade school and who found an interest in devoting his time to sketching our operators in various positions at their work.

"This series of 8 folders is the first of a lot of 24 which we will print in due time, enough to cover two years' continuity of mailing."



These Remarkable Folders Were Developed by the Storts Welding Co. to Be Used in a Direct-Mail Campaign to Customers and Prospects.

Any job-shop owner wishing to see copies of these folders can obtain a set by making a request on his letterhead to Mr. Tierney, as several hundred extra copies were printed for this purpose. They will well repay careful study by anyone engaged in the sale of welding service.

A job shop in the Middle West, doing $10,000 worth of business a year, with prospects very favorable for further increases, is to be sold. The owner has built up a large business in hard-facing agricultural and industrial equipment. Two dams costing some $7,500,000 are to be started within a few miles of the location, and the state is doing extensive highway work in the immediate vicinity. The shop is located in the heart of a thriving city, on one of the main streets. The business is completely equipped, and includes a portable electric welder. The owner wants to sell for $5000 cash. Further details can be obtained by writing The Welding Engineer, 608 S. Dearborn St., Chicago, Ill.

New Standard Code Covers Pressure Piping

Forty national organizations cooperated in preparing the American Standard Code for Pressure Piping, to serve as a guide to state and municipal authorities in drafting regulations for installation of safe pressure-piping systems, and to act as a standard reference for equipment manufacturers, architects, engineers, erectors, and others. This code has been approved by the American Standards Association. Its provisions cover:

(1) Choice of suitable materials and reference to specifications covering these materials.

(2) Designation of proper dimensional standards and methods of fabrication for the elements comprising piping systems.

(3) Listing of suitable formulas and requirements for the design of these elements and their supports.

(4) Erection of piping systems.

(5) Testing of the elements before erection, and of the complete systems after erection.

The code does not cover building heating systems operating at less then 15-lb. gauge pressure, plumbing, sprinkler systems, roof and floor drains, sewers, and the like; and valves, fittings and piping and boilers are considered outside the scope of the code, since these are covered by the A. S. M. E. Power Boiler Code. Economizers, heaters, tanks and other pressure vessels also are outside

the scope, but connecting piping comes under its requirements.

The maximum limiting temperature specified throughout the code is 750°F., except in the case of oil piping, where temperatures as high as 1100° F. are permitted in some cases.

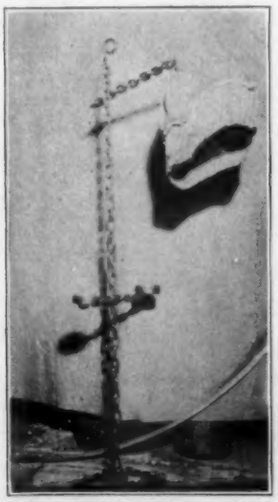
Sections of the code deal with power piping, gas and air piping, oil piping and district-heating piping. Preparation of a section on refrigeration piping is under consideration, as is also one on hydraulic piping.

The section on fabrication details provides a set of minimum requirements for the fabrication of hangers, supports, and the like; the fabrication of piping joints other than welded; the welding of piping joints; and the provision for expansion and flexibility. The chapter on welded pipe joints was prepared in cooperation with the Pipe Welding Code Committee of the American Welding Society.

Copies of this code can be obtained at $1.00 each from the American Society of Mechanical Engineers, 29 West 39th St., New York, N. Y., or from the American Standards Association, same address.

Unique Floorlamp Made of Chain

This lamp, made entirely of chain, one would expect any moment to collapse in a heap on the floor—but it doesn't. Just as the Indian fakir makes a snake stand erect, so the powers of the magician-welder enable him to make the chain



It Doesn't Collapse, Because It's Welded.

stand and support a lamp and shade. By using the arc, the welder, who was connected with The Welding Engineers, Columbus, Ohio, carefully spotted each link to the adjoining ones, making a rigid lamp standard. Though knowing how it's done, one still has a hard time throwing off the feeling that here is something that just can't be.

A Welding Engineer's Wife Speaks Her Mind

■ By MILDRED KINKEAD

(Editor's Note: At last, we are able to reveal the writer of this "column" which has been a regular feature for several issues. May her pen never go dry!)

Getting Their Ground Work

Yesterday being cooler, I drove the "jeloppy" downtown and stopped in to see an old friend, Mr. Edward Scott, president of The Cleveland Welding School. His pleasant secretary, Miss Miller, was opening the mail. She passed Mr. Scott some fan letters from former students, and I got a peek at one from Frank Scorah, foreman welder, Canadian National Railways, Winnipeg. He had taken the course last summer while on furlough after six years of welding with which he himself wasn't satisfied. Like all welders, he was enthusiastic about his work, and had written to say that he was sending two friends to enroll in the school. He expressed his friendly regard for Mr. Scott, and no wonder. He is a mighty nice fellow!

Mr. Scott showed me through his modern school, equipped with gas, electric and atomic-hydrogen processes. The school teaches fixed procedure control for welding all industrial metals, including the new alloys. Students must learn to test their own welds by scientific methods. No student may receive the school's certificate until he has put in 280 hours of work and mastered the procedures. Employers have expressed their approval of this thoroughly diversified training. Many of them send picked men to take the courses at company expense.

Alumni of the school include many nationalities, hailing from various parts of North and South America. Italian boys, according to Mr. Scott, make very good welders, and Jewish boys are not far behind. In last year's classes was Louie Logan, otherwise known as Chief Little Wolf of the reservation tribe of Onondaga Indians, of western New York state. Louie was bright, and the other fellows liked him. He wore his coarse, black hair long. It hung to his waist. The men kidded him about his girlish tresses. "Louie," they would say, "why don't you get yourself a haircut some day? That head of yours looks like an explosion in a mattress factory." Louie would grin. "Why don't you boys let hair grow?" he would answer sometimes. "You look funny to me, too, with head round like football." In spite of all the gags, Louie became a good welder.

In addition to its regular sessions, The Cleveland Welding School has special classes for disabled men. The state industrial board pays for their training. One-armed men often become expert welders, sometimes outclassing men with both arms. The school has trained a pair of deaf-mute men. Their priest brought them to Mr. Scott last summer. These handicapped students required patient instruction, of course, but were able to master the course, although a longer time was needed to teach them. The two are now welding tire molds at an Akron rubber factory which employs colonies of deaf-mutes in various plant operations.

The school has just announced a new scholarship in welding, which has been conferred upon a promising young Clevelander attending Fenn College. Mr. Scott and his faculty look forward to their responsibility of training this man in the techniques and metallurgy of welding.

* * *

Family Stuff

The young son has a new hobby. Last winter it was stamps, and spring brought swarms of small airplanes carved out of balsa wood with a razor blade. Then came a short obsession with ship-models, sloops and brigs and barkentines, and climaxed in a shining scarlet version of the *Normandie*. And now it's model locomotives. Some smart toy-maker has put out an ingenious line of these historic reproductions to build, just as the model airplane craze seems to be calming down a little. Our boy has fallen hard. We had our first inkling Monday when we came down to breakfast and spotted an 8-in. model of an ancient locomotive on the mantel shelf. It turned out to be a replica of the Tom Thumb locomotive built by Peter Cooper in 1830. Three more models have put in an appearance since then, all in gray enamel with red wheels and rivets touched up with black. The new ones are the DeWitt Clinton, 1831; the Pioneer, 1851, and the C. P. Huntington, 1863. The mantel is full now, but Bob says this is only the beginning. He wants to get the Empire State Express, 1893, and the Modern Locomotive when he has the money.

Bob is earning his spending money by airing the neighbor's dog. This animal is a sad cocker spaniel named Curly. His owner works downtown every day and Curly is shut up inside the house. Under the circumstances, a neighboring small boy is a godsend. Ours is ambitious. She pays him a dime to take Curly around the block and he has about walked the soles off poor Curly's feet. While this locomotive craze lasts, Curly is assured of plenty of fresh air.

What's New in

Equipment and Accessories

Inconel-Clad Steel Now Available

Inconel-clad steel is now being produced by the Lukens Steel Co., Coatesville, Pa., and represents a joint development by Lukens and The International Nickel Co. It consists of a layer of Inconel firmly bonded by rolling to a thicker layer of steel plate. It is available in thicknesses from ¼ to 2 in., with the Inconel cladding representing from 10% to 20% of the total thickness. The plate can be rolled up to 72 in. in width and 240 in. long.

Combining the structural features and low cost of steel with the corrosion-resistance of Inconel, this new product is applicable to heavy equipment in many industries, as proved by a long series of tests and service in a variety of fields. It is said to be especially adapted for wine-storage and fermenting tanks, fatty-acid stills, and other heavy equipment handling similar materials.

Inconel consists of approximately 80% nickel with 12% to 14% chromium, the remainder being chiefly iron. Its thermal coefficient of expansion is practically the same as steel. It resists the action of a wide range of corrosive agents and is tough, strong and highly resistant to oxidation. It is readily welded with welding rods developed for the purpose.

Protecting Surfaces Against Wear and Corrosion

"Sweat-On" and "Cast-On" are two materials recently introduced into the field of wear-resistant, corrosion-resistant overlays.

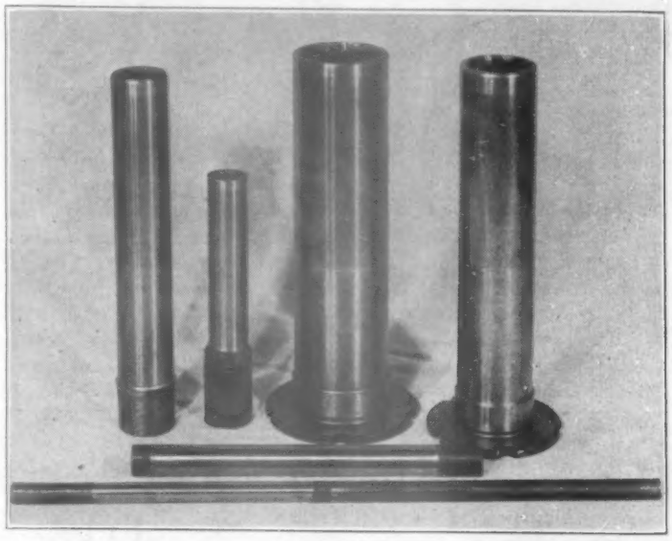
"Sweat-On" is applied by heating the surface of the metal to be processed so that the material imbeds itself in the surface or skin of the metal. "Cast-On" is liquefied and poured to fill any cavity between an easily constructed mold and the parent metal to be processed.

These new materials employ boron crystals as their base, and the same is true of the new Colmonoy inserts for oil-well tools, which are said to have a hardness of something over 9 on Mho's scale and yet great inherent strength and exceptional abrasion resistance.

All these products are comparatively light in weight. The specific gravity of the boron crystals is approximately two-thirds that of mild steel, and they are very much lighter than tungsten carbides and many other base alloys used to form wear-resistant overlays.

As prepared as Norman W. Cole, the inventor of these new materials, "Sweat-On" is furnished in the form of a crystalline powder (60 mesh or finer). It is best applied by mixing the crystals with sodium silicate (water glass) to make a stiff paste, then spreading the paste with a brush or spatula over the surface to be covered, after which the oxyacetylene torch or carbon arc is played on the overlay for a short time, which completes the operation. The surface thus treated is protected against the ravages of wear and corrosion, and even of heat.

The "Sweat-On" overlay is not continuous. The metal processed becomes impregnated with myriads of tiny particles or crystals; yet no two of them are tied to each other, and the parent metal is free to expand or contract, bend or break, without materially changing or loosening up the protecting overlay, it is claimed.



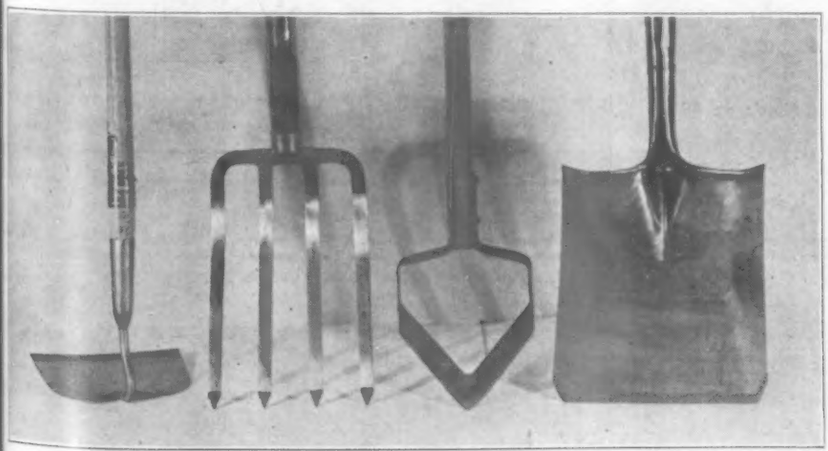
Colmonoy "Cast-On" Applied to Cylinders and Solid Shafts.

"Sweat-On" lends itself to a wide variety of applications. It can be applied to horizontal or vertical surfaces, or overhead. It can be made to follow the exact contour of irregular surfaces so that the parent metal is equally protected where there are depressions or elevations as well as on the flat. The paste is merely spread as and where desired. The flame or carbon arc does not disturb it once it is placed.

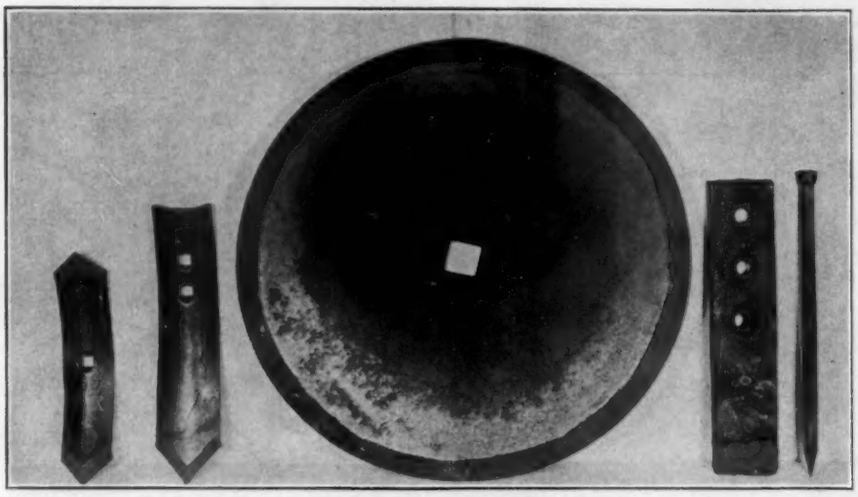
An optional application method to the forming of a paste is to bring the parent metal to a sweating heat and then dust on the dry powder. Generally, however, this does not produce as level an overlay as the paste method and it is more wasteful and not so dependable.

Metal that is protected with "Sweat-On" cannot easily be ground to a smooth, polished surface. The tiny protective crystals are too hard for easy grinding. On the other hand, "Cast-On" overlays can be ground.

"Cast-On" is applied by a very simple casting procedure to form a continuous overlay that can be ground and polished, even though it resists both wear and corrosion. This overlay metal is said to average 58 on the Rockwell "C" scale (545 Brinell) and is exceedingly tough,



"Sweat-On" Increases the Efficiency and Life of Garden Tools.



"Sweat-On" Applied to Agricultural-Implement Parts.

though its melting point is in the neighborhood of 2000° F. Furthermore, its resistance to acids is quite comparable to, if not equal to, the acid resistance of the "Sweat-On" crystals, it is claimed.

The use of "Cast-On" eliminates much of the trouble due to variance in coefficients of expansion and contraction between the cast-on metal and the parent metal, lack of fusion or amalgamation between the two, puddling of the parent metal and the overlay, and inability to patch the overlay should patching be necessary.

Further details regarding these Colmonoy products may be obtained from Colmonoy, Inc., P. O. Box 977, Los Nietos, Calif.

Machine for Cutting Pipe Intersections

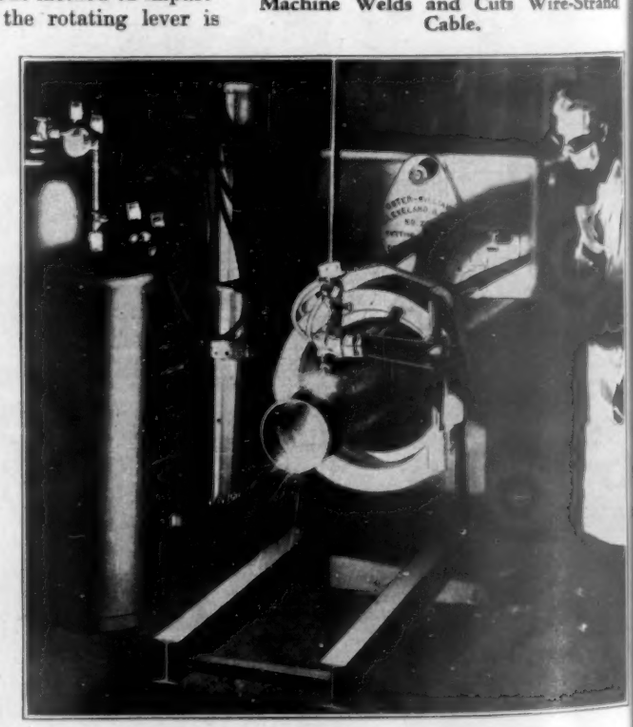
A machine for cutting pipe intersections has been developed by Oster-Williams, 2057 East 61st Place, Cleveland, Ohio, and is being marketed as the Oster-Williams No. 212 Machine. The manufacturer claims that it can duplicate in design any pattern that is required to do practically any kind of pipe-welding job, without using any cams, templates or special fixtures, and the finished surface has the appearance of a lathe-tool cut.

The cutting torch is accurately guided by an ingenious mechanism to duplicate the motion of a torch held in the operator's hand. The machine will cut any size of pipe from 2½ to 12 in. in diameter, making full-size tees or reducing tees 90°, branch reducing tees 45° to 90°, elbows, miters, Y's and blunt bull plugs, as well as cutting holes.

The machine somewhat resembles a radial drill press. The aluminum generating case is mounted on a rotating column, which can be swung in any direction and readily positioned to the end or side of the pipe for the various cuts. The pipe is placed on ball-bearing rollers, housed in adjustable supports resting on double rails mounted on the welded steel base of the machine.

If the end of the pipe is to be cut off for butt or tee welding, then the pipe is placed through the aluminum torch-carrier ring. If a hole is to be cut in the side of the pipe, the torch-carrier ring is swung around until it faces the side of the pipe. No templates are needed for the cut, nor does the job have to be laid out. A chart is furnished which guides the operator for any kind of job he wants, then he sets the machine and it is ready to make the cut. For even the most difficult cut, it is only necessary to make five simple settings.

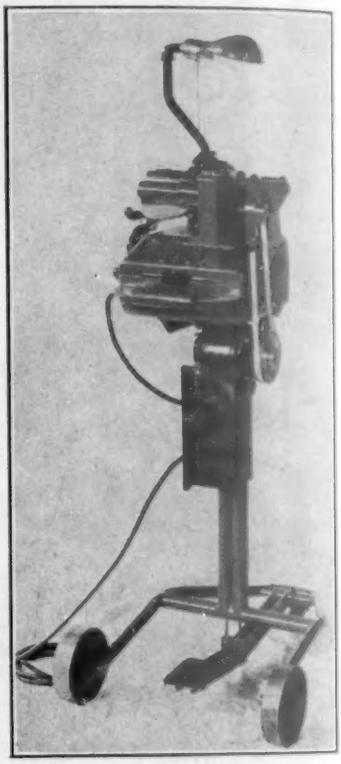
These settings are regulated by positioning a rotating beam or lever, which operates a reciprocating slide. This slide in turn controls the movement of an oscillating lever. This lever then reproduces a reciprocating movement in the torch carrier. The method of imparting movement to the rotating lever is through a handwheel located at the side of the generating mechanism case. This also produces the drive for rotating the torch-carrier ring around the pipe. The operating handwheel is located in such a convenient position that the operator can see the progress of the cut.



Cutting a Pipe With the New Oster-Williams Torch Machine.

No More Unraveling of Ends of Wire Shafts and Cables

The unraveling at the ends of flexible shafts, stranded wire and cables composed of a multiplicity of small wires,



Machine Welds and Cuts Wire-Strand Cable.

either twisted together or helically coiled, that is apt to occur during cutting of the shaft or cable, can be eliminated by the use of a new machine developed by the Eisler Engineering Co., 757 South 13th St., Newark, N. J. The manufacturer claims that this machine, which is a combination cutting, welding and trimming machine, will cut flexible cable apart or will join two pieces and trim them, without unraveling, and at the same time maintain practically the same flexibility as before.

A flexible shaft or cable to be cut apart is clamped in the welding jaws. Application of current welds the strands together and finally severs the cable. The ends of the cable are then placed in the trimmer, which is equipped with a carborundum wheel driven by a 1/20-hp. motor, and finished off. In welding two ends of cable together, the ends are first prepared as above and then welded together, after which the joint thus made is placed in a special annealing device. After proper annealing, the cable is inserted in an automatic centering device of the trimmer and the burrs of the joint ground off.

In addition to the annealer and grinder or trimmer, the machine is also equipped with a slide adjustment for closely regulating the welding current, push-button control of upset and current, foot-operated clamping jaws for holding the work, and a lamp with reflector for adequate light upon the work.

This combination welder and trimmer will handle either square or round solid rods, wire and bars, as well as flexible shafts and cables of steel, nickel, brass, copper and other metals up to 0.250 in. in diameter. It is operated on either 110- or 200-volt alternating current, and can be mounted on a bench or furnished with a movable pedestal.

Trade Literature

"A Century and a Quarter in Iron and Steel" is the title of a booklet printed in rotogravure by the Lukens Steel Co., Coatesville, Pa., in commemoration of the company's completing 125 years in the making of iron and steel. It contains historical information regarding the company and the early days of steel making, and is illustrated by many interesting ink and pencil sketches.

The economies of hard-facing and the application of Durod hard-facing materials, constitute the subject-matter of a pocket-size booklet issued by Duralloys, Inc., Graybar Building, New York, N. Y. Five different grades of electrodes and rods for hard-facing are listed. All these can be applied by either the electric or gas method.

"Rolled Steel for Machine Construction" is a pamphlet containing many interesting examples of design in which are welding and flame cutting were used. Copies may be obtained from the Illinois Steel Co., 208 S. LaSalle St., Chicago, Ill., or from the Carnegie Steel Co., Pittsburgh, Pa.

"How to Make It Wear Longer by Hard-Facing and Overlaying" is the title of a pamphlet issued by The Lincoln Electric Co., Cleveland, Ohio, explaining the advantages of hard-facing and describing applications and procedures for the six Lincoln hard-facing electrodes.

The use of arc welding in constructing a penstock, a bubble tower, a dragline bucket, two huge syphons, a pipeline, and an ocean pier, is told in an illustrated pamphlet entitled "Welding in Construction Work," published by The Lincoln Electric Co., Cleveland, Ohio.

"Industrial Head and Eye Protection" is the title of a pamphlet issued by the Chicago Eye Shield Co., 2300 Warren Blvd., Chicago, Ill., describing lenses, respirator filters, goggles, helmets, respirators, various types of masks, etc.

"Machine Design—Redesigning a Cast-Iron Shear for Arc-Welded Construction" is the title of Application Sheet No. 44, Series 2, issued by The Lincoln Electric Co., Dept. 244, Cleveland, Ohio. The design problem is continued from Sheet No. 43.

"Holcomb Safety Garments" is the title of a booklet issued by the Holcomb Safety Garment Co., 128 N. Jefferson St., Chicago, Ill., describing many types of safety clothing, including welders' sleeves, gloves, bibs and aprons, and spats and leggings.

A new type of welded steel bulkhead for oil tankers is described in detail in a booklet issued by the Lukens Steel Co., Coatesville, Pa. A wide range of test results are given in diagrammatic form.

Equipment for the testing of compressed-gas cylinders to meet the I. C. C. requirements is shown and described in a leaflet issued by Edward C. Smith, 2623 North 2nd St., Harrisburg, Pa.

"Manganal" nickel-manganese-steel electrodes, applicator (filler) bars, and wedge bars are described in leaflets published by the Stulz-Sickles Co., 134 Lafayette St., Newark, N. J.

Lenses, helmets, goggles, respirators, and other industrial safety devices are illustrated and described in a new catalog by Willson Products, Inc., Reading, Pa.

The new Metalweld "Navy Type" electrode holder is described in a folder issued by Metalweld, Inc., 26th and Hunting Park Ave., Philadelphia, Pa.

Commercial News

Gil V. Dye, formerly jobbing representative for The Linde Air Products Co. in Texas and Oklahoma, has resigned that connection and organized his own company at Houston, Texas, where he can be addressed at Box 821. He reports he is in the market for a complete line of rods and supplies to sell to jobbers. His company represents the Will-Weld Manufacturing Co. in the sale of a.c. welders, and expects shortly to announce a connection with a manufacturer of oxyacetylene equipment.

The Lincoln Electric Co., Cleveland, Ohio, will demonstrate the arc welding of high-manganese steel, high-carbon steel, stainless steel, cast iron, aluminum and copper, also light-gauge materials, in booth E-310, at the Machine Tool Exposition, to be held in Cleveland, Ohio, Sept. 11th to 21st. Arc welders will be demonstrated, and two new hard-facing electrodes will be shown.

The Air Reduction Sales Co. has opened stores in Atlanta, Ga., and Tulsa, Okla., because of the substantial growth of their business in these two cities. The Atlanta store is at 336 Spring St. N. W., and the Tulsa store at 18-20 N. Cheyenne Ave. Apparatus, gas and supplies will be carried in stock at both points.

The Gas Products Co., Columbus, Ohio, has had installed a 275-hp. Cooper-Bessemer Diesel engine, directly connected to an electric generator, for supplying power for the various plant processes. Power costs have been cut almost in half by this installation, it is claimed.

The Portland, Ore., office of the Air Reduction Sales Co. has been moved from its long-established location at 3rd and Glisan Sts. to larger quarters at 13

Northwest 4th Ave., the move being necessary to provide more space to adequately stock, display and demonstrate the company's products and supplies.

The Harnischfeger Corp., Milwaukee, Wis., will have on exhibit their line of arc welders and electric hoists and motors in booth 504 at the Machine Tool Exposition, to be held Sept. 11th to 21st, in Cleveland, Ohio.

The National Metal Spray & Supply Co. and the National Welders Manufacturing & Supply Co. are among the new tenants in a factory building located at 3283-99 East 80th St., Cleveland, Ohio.

For the making of diffraction analyses, the St. John X-Ray Service, Inc., 30-20 Thomson Ave., Long Island City, N. Y., is now using new research tubes with molybdenum, copper and cobalt targets. Specially designed instruments and cameras are also used in this work.

C. A. Schrader, 1329 E. Altgeld St., South Bend, Ind., has been appointed South Bend distributor by The Bastian-Blessing Co. for their equipment and rods. Stocks will be carried and a welding-apparatus-repair department will be maintained.

Notes From the Field

The Union Oil Co. of California, through the use of welding, is adopting a portable welded base for their oil-well draw works. Formerly these foundations were of concrete, requiring considerable time and expense in their construction, but recently the company has been welded these from salvaged steel and miscellaneous scrapped equipment. The idea is unique and provides a great saving in view of the fact that, when a well is completed, the base for the draw works can be moved to a new well location, saving the cost of installing another foundation.

John Green, veteran welder, age 61, formerly of Tulsa and Oklahoma City, Okla., died recently of appendicitis in Los Angeles, Calif. Mr. Green entered the welding business when the industry was an infant. For the past nine years he has been in the Los Angeles district, and until a short while ago was associated with the Vernon Welding Works. He was an expert oxyacetylene operator and was greatly respected by his many friends in the Los Angeles district as well as his old associates throughout the Oklahoma oil fields.

With the money earned with an arc-welding machine which he built two years ago, William Schwarzwalder, a junior in mechanical engineering at Ohio State University, Columbus, has built an automobile, consisting of a Miller Special dash-board, a Ross-Auburn type of steering gear, a Ford V-8 radiator, a Durant chassis and a body of welded stainless steel, and, according to the *Columbus Dispatch*, young Schwarzwalder intends to use it on a 6000-mile trip to Mexico. The automobile is entirely welded.

Weldall-Sprarite Engineering Service, 42-51 Hunter St., Long Island City, N. Y., has been organized by Frederic E. Wright, a pioneer in the welding industry, to operate as a welding, metal-coating and general machine-work establishment. Mr. Wright, a member of the A. S. M. E., has been identified with the welding and associated industries for the past 32 years. His former connections included the Weldrite Co., the International Oxygen Co., and more recently the Brodie System, Inc.

The South Bend Welding and Boiler Repairing Co., 122 S. Niles Ave., South Bend, Ind., conducts a general and boiler repair service and makes Lee steel furnaces. C. A. Warner, of the company, says he has found this a profitable side-line for a welding business. The concern manufactures the entire furnace and then acts as dealer and distributor for it. Mr. Warner has turned to this work in his free time, and is finding an increasing market for his product.

A large contract for welded pipe is expected to be let momentarily by the United States Engineer's office of the Zanesville, Ohio, district. This pipe will be used in relocating existing gas lines made necessary by the building of the Bolivar and Dover reservoirs in the Muskingum River flood-control project. Approximately 76,000 linear feet of steel pipe, ranging in diameter from 13 to 20 in., including couplings and casings, will be required.

The Buhler Tank & Welding Works recently opened for business at 5000 Pacific Blvd., in Huntington Park, Calif. The new shop, which is owned by W. A. Buhler, features general steel and plate work, specializing in mining and oil-refinery equipment. Mr. Buhler also owns a tank and welding shop at Cucamonga, Calif. O. G. Parkin is chief engineer and E. J. Sterkle superintendent of the new plant.

The Cloverleaf Welding and Machine Works, 1731 S. Franklin, South Bend, Ind., has experienced a 50% increase in business this year over last, states Peter M. Horvath, proprietor. Better business is keeping the concern working overtime. Besides general repairing, the concern does practically all the machine work in South Bend, there being no other company handling machine work in the city.

The United States Army Engineer's office for the St. Louis district has awarded a contract to the Treadwell Construction Co., of Midland, Pa., for 540 linear feet of 24-in.-inside-diameter welded steel dredge discharge pipe. The pipe is to be welded and delivered in 30 sections of 18 ft. each and the specifications require that delivery be made within 90 days.

The Pittsburgh Piping & Equipment Co., of Pittsburgh, Pa., submitted a low bid of $7,475 to furnish 2,425 ft. of 12-in. black-iron welded pipe for use in the construction of the Tygart river reservoir dam. Nineteen firms participated in the bidding, and the contract will be awarded by the United States Army Engineer's office in Pittsburgh, of which Major D. W. Styer is in charge.

Alexander L. Feild, consulting engineer for the Rustless Iron Corp. of America, and president of the Alloy Research Corp., has been appointed professor of metallurgy at the Carnegie Institute of Technology, Pittsburgh, Pa., where he will devote his attention to the melting and refining of steel with the object of building up a prominent department in this subject.

A contract for a welded steel plant for the Allison Engineering Co., division of General Motors Corp., has been awarded the Austin Co., Cleveland, Ohio. The plant, which will be built at Speedway, Indianapolis, Ind., for the development and manufacture of liquid-cooled aircraft engines, will include four structures, providing 41,000 sq. ft. of floor space.

E. O. Massa, owner of the Pacific Welding Works, at Cherry and South Sts., North Long Beach, Calif., has been awarded a welding contract by a mining concern near Carson City, Nev. The work, which comprises a pipeline and installation of equipment, will require about sixty days.

The American Oil Co., Pittsburgh, Pa., is expected to let a contract shortly

Microphotographs of melted beads from five different Tobin Bronze rods. Mag. 75.

UNIFORM *in* COMPOSITION... *always*

THE accompanying microphotographs present conclusive evidence that Tobin Bronze welds are consistently uniform in composition and grain structure.

Correctly made with Tobin Bronze rods, two welds... or ten, or ten thousand... will show the same high quality *always.* These five photos were made from the melted beads of five *different* rods, and each rod was selected at random from a *different* lot.

This uniformity, so characteristic of Tobin Bronze, IS worthwhile. With so many important factors in a welding job, why take any chances on the quality of your rods?

Anaconda Welding Rods are available through leading distributors. Usually shipped in bulk, they are also obtainable in clearly labeled ten-pound packages. Additional information in Publication B-13, mailed on request.

The trade-mark
TOBIN BRONZE
means
UNIFORMITY
in every rod

MELTING POINTS OF ANACONDA WELDING RODS

Material	Approximate Melting Point—Degrees	
	Cent.	Fahr.
Tobin Bronze*	885	1625
Manganese Bronze	870	1598
Brazing Metal	930	1706
Economy Bronze*	885	1625
Everdur*	1019	1866
Anaconda 520	885	1625
Phosphor Bronze A	1050	1922
Phosphor Bronze E	1070	1958
Phosphor Bronze D	1000	1830
Phosphor Bronze C	1025	1877
Silicon Copper	1083	1981
Deoxidized Copper	1083	1981
Electrolytic Copper	1083	1981
Nickel Silver	1055	1931
Ambrac*	1150	2102

*Trade-marks Reg. U. S. Pat. Off.

ANACONDA
from mine to consumer

THE AMERICAN BRASS COMPANY
General Offices: Waterbury, Connecticut
Offices and Agencies in Principal Cities
In Canada: ANACONDA AMERICAN BRASS LIMITED, New Toronto, Ontario

ANACONDA WELDING RODS

for four all-welded steel tank barges. These barges are to be used for transportation of oil and gasoline on inland waterways. There has been considerable activity along this line in recent years among several of the larger oil companies in the Pittsburgh district.

Though general welding and brazing work has been featured by the A & B Welding Co., 446 Breaden St., Youngstown, Ohio, this company, of which C. O. Armstrong is proprietor, recently entered the sheet-metal field, and is doing a nice volume of business in it.

The Lawrence Welding Co., 11 E. 14th St., Erie, Pa., recently completed a hurry-up job for the Erie Street Railways Co., in welding a manganese-steel rail switch at Erie's busiest intersection, 12th and State Sts. Further delay would have caused a traffic jam.

A 20% to 30% increase in the welding of used punch presses, lathes, drills and other machinery and machine tools has been experienced by the Detroit & Cincinnati Welding Co., 313 East 2nd St, Cincinnati, Ohio, according to Thomas Boling, a member of the firm.

Williams Brothers, contractors [illegible] Tulsa, Okla., have a contract with [illegible] North Central Gas Co. for the laying [illegible] a 162-mile oil line between Clayto[illegible] Wyo., and Bridgeport, Nebr. The li[illegible] which will be electrically welded by H. [illegible] Price, Inc., of Bartlesville, Okla., w[illegible] range in size from 4 to 12 in.

Each summer finds L. L. Nied, of t[illegible] City Welding Co., 121 E. Washingto[illegible] South Bend, Ind., one of the oldest wel[illegible] ing concerns in the city, busy with t[illegible] repair of boats. He possesses quite [illegible] reputation for his ability in this line.

· CLASSIFIED ADS ·

Help Wanted—75c per line, minimum 4 lines. Jobs Wanted—4 lines free. Other Ads—$1.00 per line, minimum 4 lines. Count 8 words to line. Add 6 words for keyed address.

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WELDING HELMETS, GOGGLES AND GLASSES

Fiber helmets with No. 10 glass (for elec.), light weight and sturdy. Price	$5.75 ea.
2x4 glasses for above, any shade	1.60 ea.
Red fiber welding goggles (for gas welding)	1.35 ea.
Non-shatter grinding and chipping goggles	1.25 ea.

Highest quality, sent C.O.D., with the understanding that you may return within 10 days and we will refund full purchase price promptly. **Pavlik Bros., Kenilworth, Ill.**

Complete Metallizing Shop—Consisting of three high-speed metallizing guns, two sand-blast units, Chicago Pneumatic semi-portable air compressor, one pressure blower for respiration, and a full line of metallizing wires. All equipment nearly new and will be sold very reasonable due to owner's ill health. Eugene Krause, 1011 Home Savings Bank Bldg., Albany, N. Y.

Excess Stock of Arc Welders—2 A.C. transformers; 3 Lincoln 200-ampere; 2 Wilson 300-ampere; also Hobart 125-ampere; Hansen 600-ampere, and others; also cables, holders, helmets and handshields. Address Au-2, The Welding Engineer.

Guaranteed Welders—Two 300-ampere Type FKW Lincoln gasoline-driven arc welders. Priced low. Completely guaranteed. Other types in stock. Dealer's correspondence invited. Service Co., 3732 Cedar Ave., Cleveland, Ohio.

Fly Ball Governors—Adapted to all makes of auto engines; belt driven, flat or V. Price, $6.50 prepaid. Satisfaction guaranteed. In ordering state style of belt. Wm. D. Alber, Beatrice, Nebr.

Bargains—Demonstrator Arc Welders. Gasoline and electric drive. 30 days' trial. Easy terms if desired. Write Ken's Exchange, Box U-851, Troy, Ohio.

BUSINESS FOR SALE

Welding Shop—For sale or lease, one of the best estab[illegible] lished and equipped welding shops in the Southwest. Ne[illegible] building, machine works, acetylene and arc welding, livin[illegible] apartment. Good dividends throughout depression. Fine tow[illegible] in irrigated district. Priced right by owner. Waggoner[illegible] Welding Works, Garden City, Kan.

Welding Shop—Fully equipped, with oxyacetylene and ele[illegible] tric equipment. An established business in a real good loc[illegible] tion. For sale by owner. Write for particulars. O K Weldin[illegible] Shop, Carlinville, Ill.

BUSINESS OPPORTUNITY

Distributors Wanted, with established business, to hand[illegible] DUROD hard-facing products. (See our ad on page 46 th[illegible] issue.) Attractive proposition available to responsible co[illegible] cerns. Duralloys, Inc., Graybar Bldg., New York, N. Y.

HELP WANTED

TOOL MAKER—WELDING AND CUTTING APPARATU[illegible]

Thoroughly skilled in manufacture, assembly, and desig[illegible] of oxyacetylene apparatus. State age, experience, reference[illegible] and salary expected. Only first-class man needed. Addres[illegible] Au-1, The Welding Engineer.

POSITIONS WANTED

Agency Wanted—Former shop owner wants agency f[illegible] good a.c. or d.c. arc welder. Must be reasonably priced. Hav[illegible] sales and demonstrating ability. Can also take on some g[illegible] equipment and supplies. Neil S. Miller, 528 Camp St., Harris[illegible] burg, Pa.

Arc Welder—15 years' experience. Seeks permanent jo[illegible] Howard B. Furman, 76 Fowler St., Port Jervis, N. Y.

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